DISCOVERY

Monthly Notebook
DAVID S. EVANS M.A., Ph.D., F.Inst.P.

Proteins
M. F. PERUTZ Ph.D.

Self-Sufficiency in Scientific Instruments

Micro-organisms on Production
G. COLMAN GREEN B.Sc., F.R.I.C.

Science in India
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Eve of Jet-Propulsion Era

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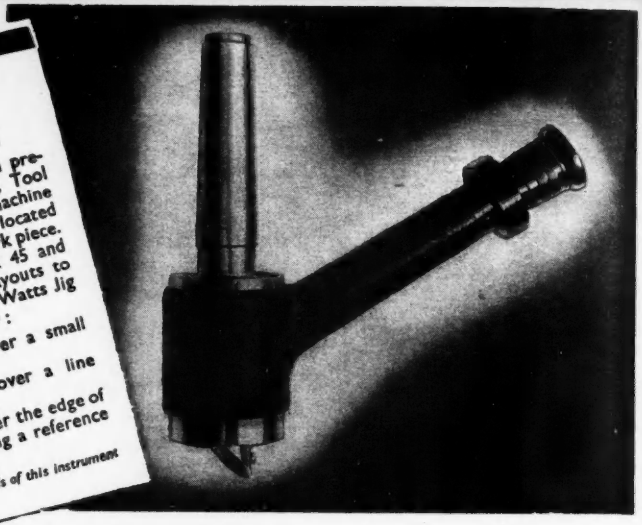

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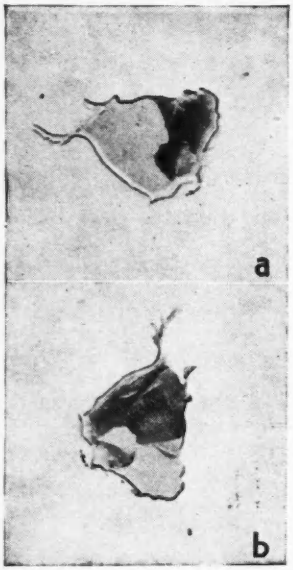

Showing pleochroic iron telluride in a sample of white cast iron under plane polarised light. B shows the same spot as A but after rotating through 90°. The crystals which are dark in A become light in B and vice versa.

By courtesy of the British Cast Iron Research Association and Mr. H. Morrogh.

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DISCOVERY

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The Progress of Science

A MONTHLY NOTEBOOK COMPILED UNDER THE DIRECTION OF DAVID S. EVANS

Goodbye Penicillin?

THE Minister of Supply was recently asked in the House of Commons what steps had now been taken to secure mass production of penicillin. Sir Andrew Duncan replied that "seven plants, six of which are pilot plants, are at present producing penicillin in this country. Nine large scale plants are expected to come into operation at various dates within the next six months. Two of them are about to start production."

His questioner, Colonel Lyons, then asked "Is the Minister cognisant of the rapid strides made in America and Canada in the use of this very valuable drug? Can he not co-operate with the authorities there to get some machinery here?" To this question he received the reply that "We are in the closest touch with organisations in America and Canada and we have the active assistance of one of the American firms in one of the plants we are putting up."

From Canada it is reported that penicillin production on a commercial scale is going ahead at two Government-owned units, and that a third unit privately financed was brought into operation within six weeks of the installation of the first piece of equipment. The U.S. War Production Board states that America now controls 95% of the world output of penicillin.

In the *Evening Standard* for October 4 it was reported that a replica of the world's largest penicillin plant, owned by the Commercial Solvents Corporation of America, is to be erected in the North of England; the equipment will be constructed in the United States and shipped to this country.

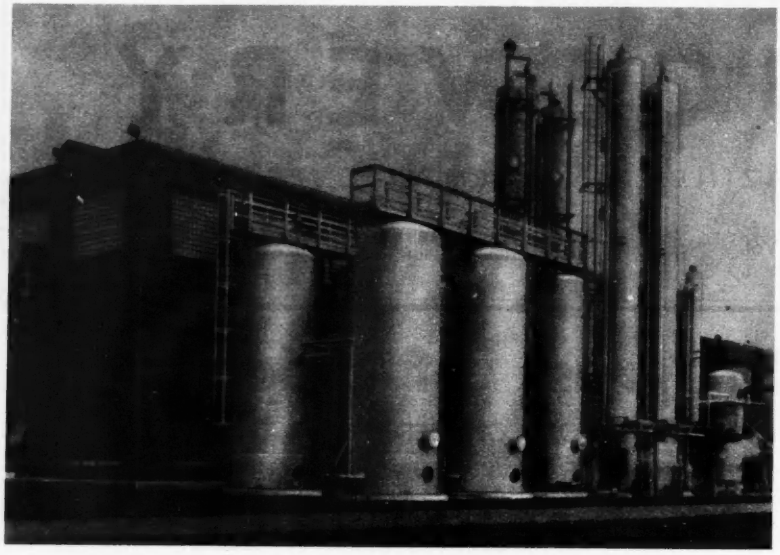
We would remind our readers, in case the facts have already been forgotten, that the curative properties of penicillin were discovered in Britain, that the realisation of its potentialities for general medical use, and the arduous tasks of developing it into a practical curative agent were undertaken in Britain. Does anyone imagine that one production plant and six pilot plants plus promises for the future are going to enable this country to make up for the lead which the United States now enjoys? How has it been possible for this country not only to lose the magnificent lead which the brilliant work of our scientists gained for her, but now to find herself so far behind that she must be indebted to the technicians of another nation for the development of these resources?

It is true that we have had greater difficulties to contend with in getting penicillin into large-scale production than has America. Material for plant construction has been scarce. Labour is short, particularly the skilled labour required for designing, building and operating new chemical plant. The past liability of almost all areas in Britain to enemy air attack may have led the Ministry of Supply to rely mainly on supplies of penicillin delivered from the U.S.A. under lease-lend agreement, or the deciding factor may have been that far greater experience of industrial mycology is available in America than in Britain.

But when all these points are taken into account do they explain why the British production of this vital drug is less than one-nineteenth of the American output? There is no sign that this country will even be able to maintain her existing relative position unless measures of the most drastic kind are undertaken. There seems every likelihood that in a year or two the United States will be able to claim quite justifiably that her own scientists have been chiefly responsible for what will be largely a United States product.

This is a stinging reflection but we can have little doubt that this is how the matter will be regarded. All we have to do is to cast our minds back to another case in which we proved ourselves incapable of making use of gifts of genius put freely into our hands—the industry based on Perkins's discovery of the first aniline dye. In that case Britain lost an industry worth millions of pounds. She allowed herself to fall into a position of dependence on a nation which was first a commercial rival and later a military enemy.

In the case of penicillin we have undoubtedly already slipped into a position of inferiority. That is likely to cost us more millions of money, and the health of who knows how many thousands of our citizens. It is a poor enough



Penicillin was discovered in Britain. Most of the world's supplies, however, come from America. This factory —at Terre, Haute, Indiana— has a monthly capacity of 40,000 million Oxford units, the drug being produced by submerged-mycelium fermentation in 12,000 gallon tanks.

consolation that this time we lose to an ally. The situation is one which renders calmness and objective comment difficult. We cannot regard "seven plants, six of them pilot plants" and a promise of nine more in six months as satisfactory. If the promise of nine plants in six months consoles us we deserve all we get. "Can the Minister inform the House as to how many more plants will be in operation in the United States in the next six months?" What is the explanation of the fact that in Canada production can commence within six weeks of the installation of the first piece of equipment?

The plain fact is that there is not enough penicillin to meet the needs of those who could benefit by its use. It is hard to believe that there would not be an acute shortage of penicillin here if the war were to stop to-morrow and our lease-lend supplies came to an end. If we cannot become indignant over the failure to make better progress in this country then we are already so far gone in apathy that we shall never succeed in insisting that things should be done efficiently and speedily when circumstances demand it.

And in the end, if it is really "Goodbye penicillin" what are we to think of the prospects of research in the future. Let us remind ourselves that the House recently debated a motion on the utilisation of scientific research. It agreed with one voice that money should be forthcoming for the general support of research on the largest scale. It affirmed its belief that only by applying the new knowledge produced by scientific investigation could Britain hope to maintain herself and her people in the post-war world. As long as we have men of the calibre of those who brought penicillin into the world—and we have such men in all branches of science—new knowledge of vital importance to every man and woman in the community will come forth in abundance. And then, to judge by what is happening to-day and what has happened in the past, it will be played with, and others with better industrial organisation and clearer vision will use what our scientists have produced. We do not know how the post-war world will shape itself; whether we shall see a recrudescence of international competition or whether there will be a development towards friendly rivalry within a framework of international co-operation, but whatever happens, this sort of wastage of the noblest gifts that man can make to mankind will be a slur and a stigma on those who are responsible.

Home for Science

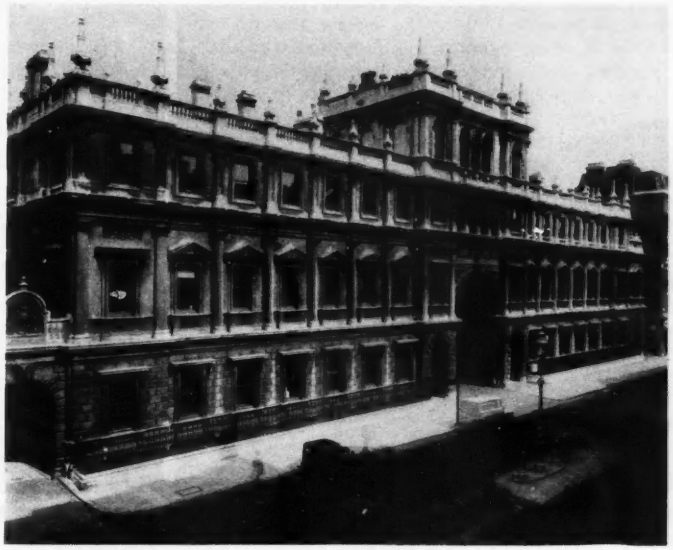
It is understood that an approach was recently made to the Government by a deputation consisting of the presidents of the various scientific societies now accommodated at Burlington House, to raise the question of more adequate housing for these bodies. This matter was aired by Sir Henry Dale in his presidential address to the last annual meeting of the Royal Society. A considerable part of Sir Henry's remarks on that occasion was devoted to a review of the various homes of the Royal Society since its foundation.

The first official home was granted by Charles II in the Charter of 1669 when Chelsea College and its estates were assigned to the Society, but this home was so unsuitable as to constitute a definite liability to the Society and the property was eventually sold back to the Crown. The Society remained for fifty years the tenant of rooms in Gresham College, until in 1710, under the Presidency of Newton, it acquired a house in Crane Court, Fleet Street, where it remained until 1778. The Society was then granted accommodation in Somerset House in a suite of rooms which, though of a suitable dignity, were inadequate in size in spite of the removal of the Society's Repository of Rarities to the British Museum.

About the middle of the nineteenth century a movement was set on foot to secure new quarters for the Royal Society and for the other scientific societies which had by that time come into existence—the Linnean Society, the

Geological Society, the Royal Astronomical Society and the Chemical Society. In 1852 an offer was made for the use of new buildings at Kensington Gore, but this was declined on the grounds that the site was too distant from central London. However, a move was effected, for the Government had acquired a few years previously Burlington House and its grounds and, at the private suggestion of the Prince Consort, the five societies concerned pressed and were granted their claim to accommodation there.

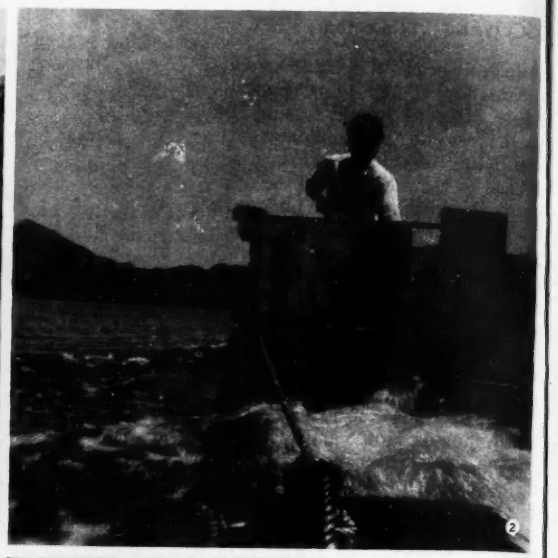
In the end, however, it turned out that Burlington House and the later building erected over the gardens at the back had to accommodate not only the scientific societies, but also the Royal Academy and the University of London. At a later date the University of London vacated their premises which were taken over by the Civil Service Commission, andby 1900 the present position had been established with the Royal Society, the Geological Society, the Chemical Society, the Linnean Society, the Royal Astronomical Society and the Society of Antiquaries occupying the side buildings of the front court, with the Royal Academy occupying the extended mansion proper and the Civil Service Commission behind that. The front court buildings also afford shelter to the offices of the British Association. As Sir Henry remarks, even in 1900 the accommodation for the Royal Society was inadequate, while to-day there is not room enough on the walls for the Society's collection of scientific portraits, nor space enough for its library. Some of the other societies, particularly the Chemical Society, which had a membership of no more than 450 at the time of the migration to Burlington House, are in an even worse plight. The membership of this society is now 5000 and its library has so far exceeded the available space that some of it is in the crypt of a neighbouring church. Again, the Physical Society, which had not been established when the others moved in, has no place at all at Burlington House.

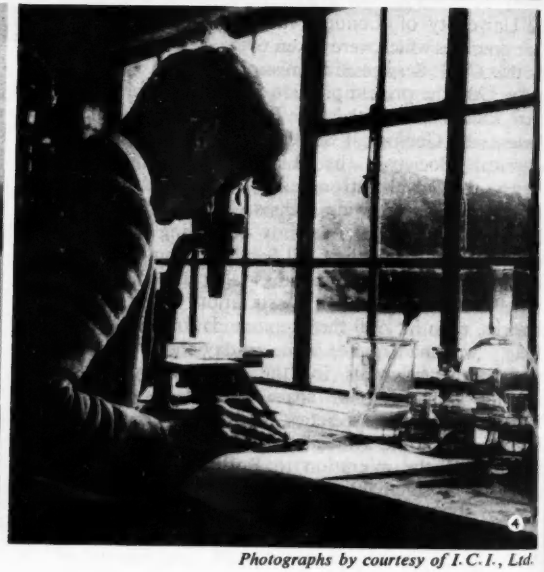


Burlington House, Piccadilly. There is not enough room for the five major scientific societies which share this building with the Royal Academy and the Society of Antiquaries.

The present housing of these scientific societies is provided by the Government, and it is clearly a fit task for the community and one from which it will benefit, to make suitable provision for a scientific centre worthy of the capital city of the Empire. To quote Sir Henry's address: "This ancient Royal Society of London, and those societies which have grown from it and round it in later years, constitute a scientific organism which is a national and imperial heritage, second to none in the world's esteem. Here are the roots of the spreading tree of science and technology, which should form a major component of our national contribution to the new world now in the making. . . . . We ought to have a scientific centre permitting them to co-ordinate their activities with economy, and giving room for change, expansion, and organic growth by budding and division, in accordance with nature's law. I think that we have the further right to expect that the home for science, in this capital city, will have a dignity symbolizing its value to the nation and the Empire, and enabling us to hold up our heads in the company of other countries, whose scientific academies, not more famous than ours, have so long been housed more worthily, and with a more generous recognition of their due place in an enlightened people's scale of cultural values".

There is indeed an overwhelming case for the provision of a scientific centre which shall visibly and concretely proclaim to those who pass by the power and glory of scientific achievement. It is to be hoped that plans for such a centre will be conceived on the grand scale, for only thus will the danger of overflow within a few more years be averted. It is also to be hoped that the grandeur of such a scheme will not make it forbidding. We have heard much in recent years of the necessity of bringing an understanding of science to the ordinary man in the street. Would it not be fitting if such a centre when created were to include one organ deliberately designed for the interpretation of science to the public? Let there be demonstrations and lectures, a planetarium, cinema shows. Let the public be made aware of a right and an opportunity to make personal contact with the scientific world. Above all, let the surroundings be at least as comfortable and attractive as those met with in a modern cinema, and let the activities be advertised as widely. It would be most unfortunate if science were made even more inaccessible by its acquisition of a new centre. Science is by nature dignified, but not high-hat, as the essentially democratic motto of the Royal Society reminds us.





Photographs by courtesy of I.C.I., Ltd.

1. Close-up of the dam between Loch Craiglin and Loch Sween.

2. Fertilising the loch. Hundredweight sacks of nitrates and phosphates are shovelled into the loch behind the propellor of a motor-boat, so ensuring even distribution and dispersal of the fertilisers.

3. By means of a collecting bottle samples are taken from the loch at intervals to find out how the plankton population has increased after application of the fertilisers.

4. The samples are examined microscopically.

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An Experimental Fish Station

THE fishing industry, like the agricultural, suffers from the disadvantage of alternations of scarcity and plenty. In some seasons the harvest may be so large that hundreds of tons of fish have to be returned to the sea; in others the normally fruitful fishing grounds may yield such small catches that their sale is insufficient to cover the expenses of the trip. Such unpredictable fluctuations have obvious social and economic consequences. In the past, attempts to introduce more stable conditions into the fishing industry have followed a policy of conservation and restriction. The recently published results of a marine biological experiment carried out in Scotland suggest that a more progressive policy, based on controlled development and production, may be possible in the future.

The growth of fish has long been known to depend on a complex food chain in which the ultimate, and most important link is the plankton. Plankton is the collective name given to a drifting population of minute plants and animals. Although the organisms of which the plankton is composed are of microscopic size their enormous numbers make them a most important article of food for larger organisms such as water-fleas and the larval forms of copepods (small crustaceans) and lamellibranchs (molluscs with two shells). The latter in turn provide food for fish such as herrings, mackerels and anchovies.

If the plankton population of the sea could be increased this would result in an increase in the numbers of the other marine organisms which rely, directly or indirectly, on plankton as a source of food. The bulk of the plankton consists of minute plants which, like other plants depend for their growth on sunlight and certain mineral salts. To augment the supply of sunlight by artificial lighting for instance, is not practicable but additional mineral salts, such as nitrate and superphosphate, can be cheaply obtained in large quantities. Investigations of the effect of adding mineral salts to a dammed-off area of the sea were commenced in 1942.

The site chosen for the experiment was Loch Craiglin, a small arm of Loch Sween, in Argyll. This loch communicates by a narrow channel with the large northern arm—Sailean More—of the main loch. This channel was closed by a dam and sluice-gate. The volume of water thus shut off had an area of some eighteen acres, and a volume of about 2,000,000 cubic feet. Its maximum depth was 15 feet, the average depth being 4 feet.

Fertilisers were first added to the waters of Loch Craiglin in April 1942. During this first year a total of 600 lb. of sodium nitrate and 400 lb. of superphosphate were added, amounts calculated to bring the mineral content of the water of the loch to 5-10 times that of the adjoining open sea. In 1943 twice as much fertiliser was added and early in 1944 a further 600 lb. of nitrate and 200 lb. of superphosphate. The results of the experiment have substantiated the theory on which it was based. In interpreting the results due allowance has been made for normal seasonal fluctuations by comparing them with those found in the waters of the adjoining open loch, Sailean More, where conditions were practically identical except for the addition of fertilisers.

The direct effect on the plankton was first studied, and some typical results may be quoted. On December 30, 1942, one day after adding the fertilisers, the number of μ-flagellates—from the economic point of view one of the most important of the organisms composing the plankton—was 1,600 per cubic millimeter. By January 31 it had risen to more than 8,000, in contrast to a maximum of 2,000 for Sailean More during the same period. The increase in other types of plankton was slower, but no less definite. The plankton increase was reflected in an increase in the next link in the food chain, the bottom fauna of which the main food of flat fish is composed. By August 1943 the bottom fauna had increased by more than 200 %.

Between April and July 1942 the waters of the loch were stocked with 2,700 small flounders and 600 plaice. Of the latter 425 had been marked with numbered identification discs. In April-July 1943 a further 1000 one-year-old flounders and 21,000 newly-hatched fish were added. The growth of the flounders was very strikingly greater than under normal conditions in the open sea. During the first year they grew four times as fast in length and sixteen times as fast in weight as flounders from the neighbouring Loch Killisport from which they had been taken originally. In less than two years they completed growth which would normally have taken 5-6 years.

With the marked plaice the results were not so striking. Most of them had their identification discs torn out, but in spite of this profound setback their growth was as good as that of plaice grown under normal conditions. Unmarked plaice, however, like the flounders, showed a greatly increased rate of growth, completing 2-3 years of normal growth in little more than one year. They thus approached the growth-rate of plaice transplanted to the Dogger Bank and similar areas characterised by an abundance of food and a relatively sparse fish population.

The results of this experiment indicate that fish stop growing in the winter in normal waters largely because of lack of suitable food. Climatic factors are of smaller importance. In the Loch Craiglin experiment it was found that the added minerals were used up very rapidly. Even when sufficient nitrate and superphosphate was added to increase the mineral content to four times the normal winter maximum only traces of the excess were left four or five days later. This rapid utilisation of mineral salts suggests that fish farming of this type need not be confined to dammed-off or sheltered waters but might be carried out in the open sea. Artificial fertilisers are already produced cheaply on a very large scale for agricultural purposes. By their use in tons instead of in pounds it may well prove possible to build up rich and dependable fishing grounds in areas reasonably free from currents which would carry the fertiliser away before it could be properly utilised. An artificially prepared ground would have the advantage of natural ones in that it could be selected with a view to transport facilities and, particularly where flat fish are concerned, a bottom suitable for the use of drag nets.

REFERENCE

"An Experimental Fish-Farm": *Nature*, 1944, **153**, p. 483.

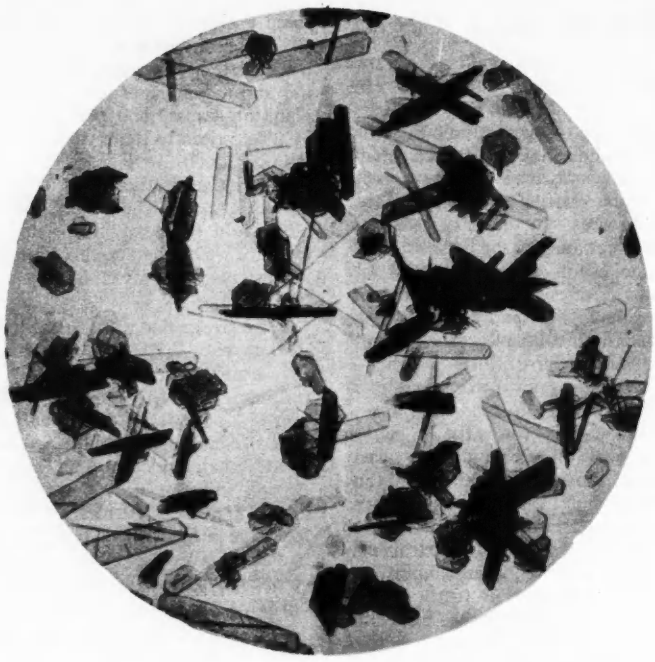


FIG. 1.—Photomicrograph of hæmoglobin crystals. Their length may vary between a hundredth and a half of a millimetre.

PROTEINS

M. F. PERUTZ, Ph.D.

DURING the war much has been written in the Press about proteins as an essential part of the human diet; we are being told that each of us needs a certain minimum of protein food if our strength and vitality is to remain unimpaired, and this food is supplied to us in the form of meat, cheese, eggs, milk and, if we are lucky, fish. In this article I shall try to show why we need protein food by explaining what proteins are and what parts they play in a living organism.

It is hardly necessary to describe the appearance of proteins because their sight is familiar to all of us. The bulk of the animal body, including muscle, skin, hair, and part of the bones, consists of proteins. Although plants are mainly built of other substances, proteins are of vital importance for all of them. Proteins are in fact so closely and peculiarly associated with all manifestations of Life that they may be regarded as its basic components. The variety of functions which they can fulfil is almost endless; they provide resilience in bones and tendons, power in muscle and protective cover in the form of skin and hair. Even the hereditary factors in chromosomes which ensure the continuance of the species seem to consist largely of protein. Finally, proteins provide a kind of chemical factory which is instrumental in carrying on the metabolism of the body. It is found that any particular physiological function in the organism is fulfilled by chemical units or *molecules* specially designed for the purpose. Nearly all these specialist molecules are proteins and each kind is usually capable of doing one job and one job only. Alcoholic fermentation by yeast may be quoted as an example of the extreme to which specialisation is carried even in the metabolism of a simple cell. In the early days of biochemistry it was thought that yeast produces an enzyme called zymase which turns glucose into alcohol and carbon dioxide. In the meantime biochemists have discovered that in the course of its transformation to alcohol, glucose passes through at least a dozen intermediary stages, and that each chemical reaction leading from one stage to the next is induced by a different enzyme which specialises on this one reaction only. Thus the supposedly simple enzyme zymase has turned out to be a complex system of different enzyme molecules, each of them carefully balanced and adjusted to do its own job at just the right speed to keep in step with the others.

In view of the vast variety of functions which proteins can perform one would naturally expect them to differ widely in their chemical composition. In actual fact it is

found that they all contain much the same elements, namely carbon, hydrogen, oxygen, nitrogen and usually sulphur, and that the relative proportions of these elements differ only within narrow limits. More detailed analysis reveals that these elements are combined into certain sub-units which are common to all proteins and which are known as *amino-acids*. Twenty-three different kinds of such amino-acids[1] are known with certainty at the present moment and the existence of others is suspected. Their name implies that each of them carries at least one amino (basic) and one carboxyl (acidic) group which enable them to form salts with both acids and bases. The configuration of these two groups is alike in all amino-acids, so that the twenty-three different kinds are distinguished merely by the nature of their side chains. (Fig. 2).

Peptide Linkage

The most essential feature of amino-acids is their capacity to combine with each other so as to form chains of great length. The joint which links two amino-acids together is made between the amino group of one acid and the acidic group of a neighbouring one, as illustrated in Figs. 2 and 3. It is seen in Fig. 3 that this joint still leaves the tyrosine molecule at the top with one free amino group and the alanine molecule at the bottom with one free carboxyl group, so that each of them in turn can form bonds with other amino-acids. By joining more and more amino-acids together in this manner chains of very great length can be built up. These are called *polypeptide chains*, because the bond between neighbouring amino-acids which I have just described is known as a *peptide bond*. Chemists have succeeded in preparing such chains synthetically and have shown that the artificial compounds have many properties in common with degradation products of natural proteins. The most important one of these properties is the capacity of intestinal juices to split synthetic chains in the same way as they split proteins which have previously been "digested" by the gastric enzyme pepsin. The peptide link has thus been proved to be fundamental for the structure of all proteins, and although nobody has yet succeeded in making a protein synthetically, it is believed that no other strong chemical bond of like importance occurs.

How is it that proteins can show such great versatility if Nature uses no more than twenty-three different amino-acids to build up polypeptide chains? Let us consider for a moment how many different chains could be made if we started with a total of twenty-three amino-acids, no two of which are alike. According to the laws of statistics, the number of different chains that could be built from twenty-three different units is

$$\frac{1 \times 2 \times 3 \times 4 \times \ldots\ldots \times 23}{2} = 13 \times 10^{21}$$

or 13,000 million million millions. If the chain contained many hundreds of amino-acids instead of just twenty-three, as many proteins do, then the possible number of different arrangements of the twenty-three types along the chain is hardly conceivable. But this is not all. Quite apart from

[1] Strictly speaking two of them are not amino-, but imino-acids.

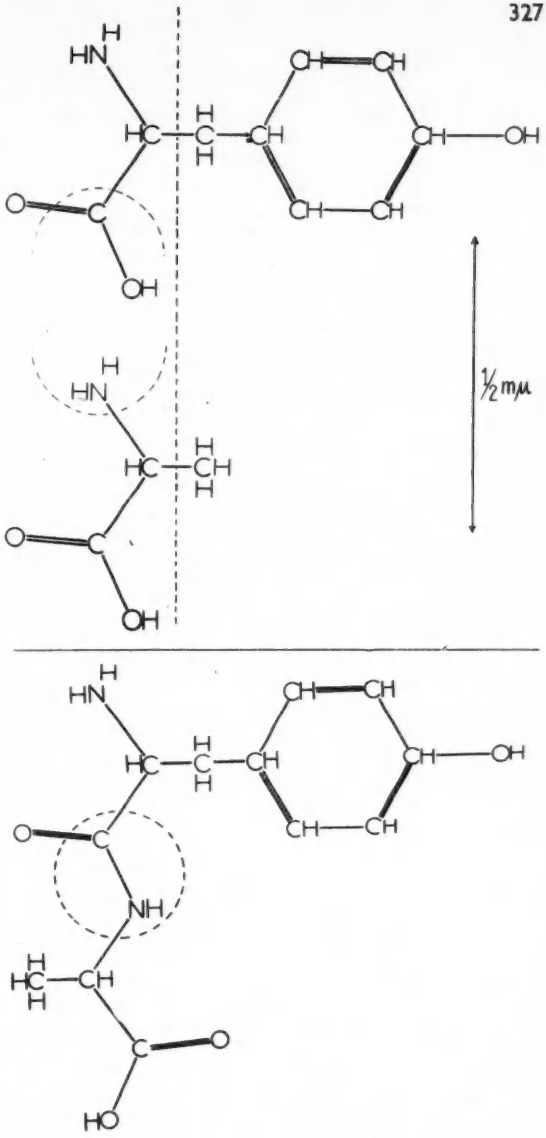


FIG. 2 (above).—Two typical amino-acids as found in proteins. The upper one is tyrosine, the lower one alanine. The symbol *C* stands for carbon, *N* for nitrogen, *O* for oxygen and *H* for hydrogen. The portions of the two molecules on the left of the line are identical and moreover are the same in all amino-acids; they form the backbone of the polypeptide chain. The portions on the right of the line are different in each amino-acid and are known as their side-groups. mμ stands for millimicron and equals one millionth of a millimetre. The upper semi-circle marks a free carboxyl group, the lower one a free amino group; the two can be joined together with the elimination of one molecule of water.

FIG. 3 (below).—The two amino-acids of Fig. 2 are now linked together by means of a peptide bond, shown inside the circle. They form the beginnings of a chain running from the top to the bottom of the picture. More amino-acids could be joined on at each end.

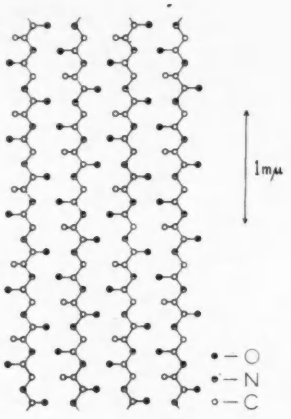


FIG. 4.—Silk thread. Bundle of straight polypeptide chains as it probably occurs in natural silk. Only the carbon, nitrogen and oxygen atoms are shown, the hydrogens have been omitted.

the possibilities of chemical variation a tremendous variety of geometrical configurations present themselves. Polypeptide chains may form straight bundles, or coil up in one plane or fold up in space in many different ways. Each of these configurations will give rise to different physical and chemical properties, thus enabling proteins to fulfil almost any mechanical or chemical function in the organism.

Fibres and Fabrics

A bundle of straight chains is obviously the simplest configuration which polypeptide chains can assume; nevertheless only three instances of this have been found in nature, one being collagen, which is the principal protein of bones and tendons; the others are silk fibroin (Fig. 4), and keratin of bird's feathers. The latter is interesting for the close similarity between the way the silk-worm produces its thread and modern methods of artificial silk manufacture. The silk-worm prefabricates its polypeptide chains in soluble form in the silk gland which occupies a considerable part of its body. By pressing the fluid through a narrow opening and precipitating the protein at the same time the silk-worm produces a fibre. This is then made stronger by stretching before the silk-worm spins it around its body so as to provide itself with an armour during pupation.

In general, bundles of folded chains rather than straight ones are met with in natural fibres, since elasticity is often a more desirable quality than sheer rigid strength. Such folded chains can be stretched under water and made to recoil to their original length when the tension is removed, rather like a rubber band. Animal hair, nail and horn are all made of folded chains built on very similar patterns. If hair is heated excessively, then the elasticity of the molecular springs is destroyed and the hair becomes permanently set, a property which hairdressers discovered long before the scientists and which they used for providing ladies with permanent waves. Elastic bundles of polypeptide chains also play a most important part in muscle; this consists mainly of a fibrous protein called *myosin* which actually expands and contracts with every twitch of the muscle. The patterns of folding of the polypeptide chains in hair and in muscle appear to be very similar, yet it is only muscle which has the capacity of transforming chemical into mechanical energy by using the decomposition of glucose to supply the energy for its contraction. Although the final link in this remarkable transfer of energy has recently been discovered in the form of an organic phosphorus compound, its mechanism is still only incompletely understood. We cannot yet see how the myosin chains take up the energy or what makes them contract. It is not even clear whether single chains do actually contract, seeing that the chains in relaxed muscle are already folded, and it is hard to conceive how such folded chains could contract any further. It has therefore been suggested that the contraction might be achieved by the coiling up of whole bundles of chains without involving any alteration in the pattern of molecular folding.

I mentioned earlier that polypeptide chains can also form two-dimensional fabrics or networks. Such networks probably occur in the membranes of cells, but so far little is known about them.

Boiling an Egg

The most important proteins are the globular ones where the polypeptide chains are arranged in the form of a three-dimensional network. Their part in the organism cannot be too highly stressed. It is no exaggeration to say that plant and animal life consists of the sum total of the activities of globular protein molecules. They are as vital to amoebae as they are to mammals and are indeed the most essential components of every living organism. In the following paragraphs I shall endeavour to show some of the tasks which they perform and to describe the mechanism by which they do it.

The variety of properties which globular proteins may exhibit is as endless as the number of configurations which a polypeptide chain can assume. Nevertheless there are some characteristics which are common to many proteins and one of these is solubility. Most of the globular proteins are more readily soluble than the fibrous ones; this is not surprising, for to be effective as enzymes or carriers of oxygen, proteins must either be dissolved in the body fluids or at any rate act in the presence of water. Their solubility is easily lost by heating, which coagulates them and destroys their biological activity. The boiling of an egg, for example, not only kills the embryo but also coagulates the proteins in the egg. The difference between an intact protein and a boiled one seems to be that in the former the polypeptide chains are arranged in a definite pattern and form molecules of specific weights and dimensions, while the boiled proteins merely consist of tangles of chains of indefinite length and shape. We can picture the process of coagulation if we imagine that heat makes the neatly ordered chains wriggle so violently that they unfold and get entangled with their neighbours in the process. Once the orderly configuration of the

chains is lost they are generally are unable to regain it, even if we try to disentangle them by re-dissolving the coagulated proteins in strong acid.

Protein molecules are much too small to be seen under any microscope using light; their size and shape, therefore, have to be inferred indirectly. The weight of the smallest known protein molecule, secretin, is 5,000 times larger than the weight of a hydrogen atom, that of the largest one, hæmocyanin, nearly 7,000,000 times larger. If we regarded the molecules as spheres, then their diameters would vary between 2·3 and 25mμ (mμ means a millimicron and is equal to a millionth of a millimeter). In order to give a better idea of the smallness of a protein molecule, we may compare its diameter to that of an ordinary pin's head. The number of protein molecules of the smallest size that could be accommodated in a pin's head is about the same as the number of pin's heads that could be packed into a sphere of the diameter of Regent's Park.

Protein Crystals

Many proteins can be crystallised and few people realise that protein crystals can be as beautifully shaped and as transparent as ice crystals (Fig. 1). There are no two proteins whose crystals are exactly alike; therefore the crystal shape can serve for identifying proteins. This differentiation extends to crystals of the same protein from two different animal species and becomes more pronounced the further removed the species are from each other.

The different crystal types merely express the individual features which distinguish protein molecules from each other. What these features are can only be surmised at the moment, but the discovery of the individuality of proteins, or *specificity* as it is usually called, has given rise to most spectacular developments in medicine. The practice of vaccinating or inoculating people against certain diseases derives its scientific background from "specific" reactions of proteins.

Proteins as Protectors from Infection

In 1796 Edward Jenner, a physician in Berkeley, Gloucestershire, made a vital experiment. He had noticed that dairymaids whose hands showed small pustules from cowpox remained unaffected while an epidemic of smallpox swept the countryside. Jenner tried to transfer the dairymaid's resistance against smallpox by inoculating a boy in the arm from the pustule of a young woman who was infected by her master's cows. The experiment was successful and the boy remained immune against the smallpox. To-day we vaccinate babies with cowpox soon after they are born; as a result smallpox, once a dreaded disease killing hundreds of thousands every year, has practically vanished from the civilised world, and many other once menacing infections have been rendered harmless by timely vaccination.

How does vaccination protect? In order to vaccinate against a certain disease small quantities of either dead bacteria or a non-virulent form of the disease carrier or bacterial extracts are usually injected. As soon as these foreign particles invade the organism, an intricate system of defence is set in motion and a special blood protein called gamma-globulin becomes sensitised against the intruders. If, after a lapse of time, the *same* intruders invade the blood-stream in more formidable numbers, then the sensitised globulin molecules will at once set upon them and herd them together into impotent clots which can easily be eliminated from the system.

A remarkable feature of the sensitised globulin molecules is their specificity. They will only react with the particular type of intruder against which they were sensitised and with no other. If the sensitised globulin is so specific, how is it then that vaccination with cowpox will protect us against smallpox? It so happens that the cowpox virus is such a very close relation of the smallpox virus that the globulin sensitised against the one is equally effective against the other. Hence infection of a man with the harmless cowpox virus renders him immune against its deadly relative—smallpox.

Great advances in understanding the mechanism of immunity reactions have recently been made. Scientists postulated that during the sensitising of an animal against an intruder, certain chemically active groups on the surface of the intruder particle act as templates against which the globulin molecules re-arrange their polypeptide chains, so as to fit those templates as a key fits a lock. There is one qualification to be added to this picture; while only one end of a key fits a lock, both ends of a globulin molecule must adapt themselves to the templates on the intruder's surface if they are to fulfil their function effectively (Fig. 5).

Now supposing the animal has been sensitised against typhus bacilli, and those bacilli later invade its blood-stream, how do the globulin molecules contrive to clot them? Each bacillus will attract hundreds of sensitised

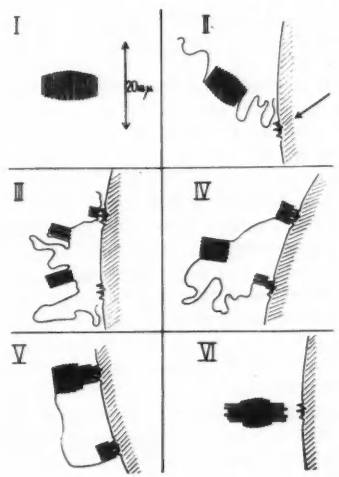


FIG. 5.—Formation of a sensitised globulin molecule (schematic). *I* shows a normal globulin molecule consisting of folded polypeptide chains. The scale is only approximate. *II.* The globulin molecule unfolds as it approaches a pneumococcus. The arrow indicates an active group on the surface of the coccus. *III, IV* and *V.* The polypeptide chains adapt themselves to fit the active groups on the surface of the coccus. *VI.* Sensitised globulin molecule with its chain rearranged. (After L. Pauling.)

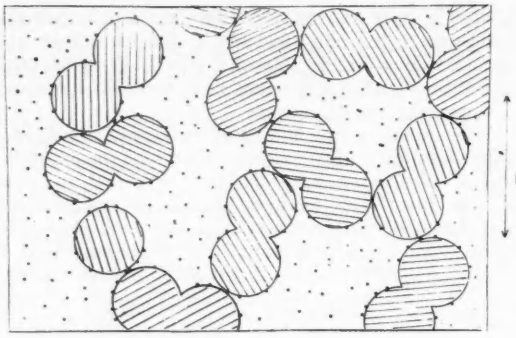


FIG. 6.—Clotting of pneumoccoci (large) by globulins (small). 1μ means one micron and equals 1/1000 of a millimetre or 1000 mμ.

globulin molecules which will attach themselves to its surface by one of their activated ends, while trying to hook on to a second bacillus with the other. The globulins which already cling to the second bacillus will in their turn try to capture a third and so on, until thousands of bacilli are clotted together in a helpless mass (Fig. 6).

This ingenious theory was followed up by showing that globulin can be sensitised outside the animal's body. A solution of globulin from ox blood was kept at an elevated temperature together with a suspension of pneumococci, the bacilli which cause pneumonia. After several days the cocci were filtered off again. By then the globulin molecules in solution had evidently become sensitised, because experiments showed that they were now able to clot much larger numbers of pneumococci than had been contained in the original suspension. The application of moderate heat had obviously accelerated the thermal motion of the polypeptide chains of the globulin molecules, thereby enabling them to change their configuration so as to fit on to the active groups on the surface of the pneumococci. In this way a slight change in the arrangement of the polypeptide chains transformed inactive globulin molecules into protectors against pneumonia.

Although this experiment is most illuminating in illustrating the mechanism of sensitisation against infection, there are many important questions which remain unanswered. Consider once more the vaccination against smallpox. We know that a successful vaccination will protect a person from the disease for about seven years. We also know that the life of the average γ-globulin molecule in the blood-stream must be of the order of days or weeks at the most, and that globulin molecules created during the original vaccination break up in due course and are eliminated from the blood-stream. In common with the other blood proteins the globulin molecules are not a static feature of the organism, but are continuously being renewed. The cowpox virus particles used for the vaccination, on the other hand, surely cannot last out for long in such hostile surroundings, and their number must soon become exceedingly small. How then does the organism manage to keep the capacity of making anti-cowpox globulin for seven years? This question cannot be answered until much more is known in general about the way in which protein molecules are built up in the animal body.

The Oxygen Factory

Every animal needs oxygen for the combustion of food which supplies it with energy. The combustion takes place in the tissues and the oxygen has to come from the air. Man consumes oxygen at the rate of about ½ pint a minute, while a whale needs over 12 gallons a minute. Now it is impossible to keep up an oxygen supply of that magnitude by diffusion of air through the skin or by transportation of air dissolved in the blood. Higher organisms therefore need oxygen carriers, i.e. molecules which can combine with oxygen and set it free wherever it is wanted. In vertebrates the oxygen carriers are molecules of hæmoglobin, a solution of which is enclosed in the red blood corpuscles. The effect of hæmoglobin can best be illustrated by trying to visualise what would happen in its absence. Without hæmoglobin the amount of molecular oxygen that could be stored in our blood would be reduced from two pints to about $\frac{1}{25}$ of a pint. In other words, the heart would have to pump the blood at about 50 times the normal rate in order to keep the tissues supplied with oxygen.

The hæmoglobin molecule is one of the most remarkable chemical substances known. It consists of four red pigment groups known as hæms and a colourless protein residue called globin. At the centre of each of the four hæms is an iron atom which can combine with one oxygen molecule. Thus each hæmoglobin molecule can transport four molecules of oxygen. The combination with oxygen takes place in the blood vessels which permeate the lungs from where the oxygen-rich or arterial blood is pumped to the tissues; here the oxygen is taken over by other proteins while the oxygen-free or venous blood returns to the lungs. In a test tube, shaking of a hæmoglobin solution with air causes oxygenation and turns it bright red; connection with a suction pump sets the oxygen free again and changes the colour of the solution to purple.

There is nothing remarkable about that to the layman's eye. On the other hand, the chemist whose concern it is to manufacture oxygen from air cannot fail to admire Nature's ingenuity, seeing that no one ever succeeded in producing a chemical substance that can be made to combine with oxygen and give it off again by using no stronger agent than a small change in pressure. If the chemical engineer wants to make oxygen he has first to liquefy the air by cooling it to −200°C. under high pressure and then to subject the liquid air to fractional distillation. If hæmoglobin could be used instead, the number of horse-powers required to produce one cubic foot of oxygen would be reduced to a fraction of the present requirements, in addition to the saving of much costly machinery. Unfortunately hæmoglobin, once it is removed from the animal body, is too unstable a substance to be used on a factory scale.

Hæmoglobin is typical of the specificity which is so characteristic a feature of proteins. Experiments show that any change in the hæmoglobin molecule, however slight, either modifies or destroys its capacity for reversible combination with oxygen. Hæm by itself will not act as an oxygen carrier, nor will it do so if it is linked to any

protein other than globin. If globin, on the other hand, is linked to pigments which differ from hæm in more than a trifling detail it fails to transform them into oxygen carriers.

Sir Joseph Barcroft recently demonstrated how a slight change in its protein component can influence the oxygen affinity of the hæmoglobin molecule. He was experimenting on the problem of fœtal respiration when he made the surprising discovery that the hæmoglobins of mother and fœtus are not the same. To explain this it should perhaps be pointed out that contrary to most people's belief the mother's blood does not flow through the fœtus. The fœtus has its own circulatory system which is connected by the umbilical cord to the placenta where it terminates in a multitude of fine capillaries. There the blood of the fœtus comes into close contact with the mother's blood which is pumped through the placenta in a similar but entirely separate system of capillaries. How then does the fœtus get its oxygen? Nature's solution is as ingenious as it is simple. The oxygen affinity of the fœtal hæmoglobin is slightly greater than that of the mother's hæmoglobin, which results in the oxygen migrating through the walls of the capillaries from the blood of the mother to that of the fœtus. So far as could be ascertained, the only difference between the two hæmoglobins lies in their different affinities for oxygen. However, there must be a molecular cause to account for the change in behaviour, and in the absence of any difference in chemical composition the explanation is likely to be found in a different arrangement of the polypeptide chains in the globins of mother and fœtus.

Hæmoglobin is generally confined to vertebrates and occurs only rarely in other animal groups. A variety of different oxygen carriers has been discovered amongst invertebrates.

Some worms have a pigment which differs from hæmoglobin in being red in the oxygenated state and colourless when reduced. Snails and crabs have a blue oxygen carrier which is found in the serum and not, as hæmoglobin, in corpuscles. The blue colour is due to a substance which is called hæmocyanin; this contains copper instead of iron. There even exists a marine worm with green blood containing a pigment that is closely related to hæmoglobin. All these substances are proteins, hæmocyanin having the distinction of being the largest molecule found in nature.

Enzymes

If the chemist wants to break down a protein into small fragments or build up a complex organic molecule he uses high temperatures and pressures, strong acids and alkalis, powerful solvents, extreme vacuum and many other devices. The living organism has to perform the same reactions at 100°F., at atmospheric pressure and without any solvent other than water. Instead of high pressure cylinders and fractional distillation columns the organism uses enzymes.

Each enzyme specialises on one particular chemical reaction which it induces without apparently getting changed or used up in the process. Take pepsin, for instance, a gastric enzyme which splits proteins into sub-units of medium size; a pepsin preparation can split many times its own weight of protein without undergoing any noticeable change. Enzymes usually act by accelerating chemical reactions which, in their absence, would proceed imperceptibly slowly.

The variety of enzymes is baffling, as each of the many chemical reactions in nature is induced or "*catalysed*" by an enzyme specially adapted for the purpose. There may be thousands of different enzymes, but rather less than two hundred of them are known and fewer still have been isolated and purified. All those isolated up to date are proteins and most of them are concerned either with the breaking down of food in the digestive tract of animals or with the further degradation of digested food in tissues and cells. Little is known as yet about the class of enzymes which may one day become the most interesting one of all —those enzymes which induce the building up of proteins and other molecules from the small fragments which the digested food supplies.

It is highly probable that all chemical reactions which occur in a living being are catalysed by enzymes, many of which are still unexplored. Nor is much known about the mechanism by which these substances contrive to induce reactions. Enzyme chemistry, therefore, is still to some extent a virgin field which offers great opportunities for research, despite the impressive volume of work that has already been done.

The Body Synthesises Proteins

It may be opportune at this point to provide an answer to the question asked at the beginning of this article, namely: why we have to eat a certain amount of protein food in order to keep fit? Why can't we live on a handful of rice or a loaf of bread? The explanation is this. All proteins we eat are broken down by enzymes in the digestive tract until the fragments are small enough to diffuse through the membranes of the gut and pass into the blood-stream, that is to say the enzymes reduce the length of the polypeptide chains until they consist of no more than a few amino-acids. These fragments are then used by the organism to synthesise its own specific proteins, by methods still unknown. The essential point is that our organism does make its own proteins, but is incapable of producing many of the amino-acids needed for that purpose. These amino-acids, therefore, have to be provided in the food, particularly to growing children, and their absence in the diet for prolonged periods impairs our health, due to our inability to replace the normal wastage of protein in the organism. This does not imply, of course, that a diet rich in proteins is sufficient by itself. To make effective use of them, the body must also be adequately supplied with vitamins and minerals, and take in sufficient calories, no matter in what form.

Protein Physics

One of the difficulties of protein research is that the molecules are too small to be observed under a microscope and yet too large for chemical analysis. This state of affairs induced scientists to develop a variety of physical methods which allow us to get a glimpse, at least, of the

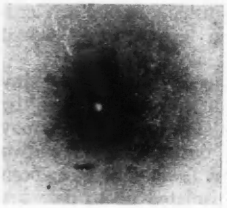


Fig 7

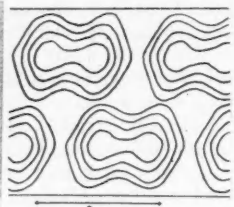


Fig 8

Fig 9

FIG. 7.—X-ray diffraction photograph obtained by rotation of a small hæmoglobin crystal in a narrow beam of X-rays. Each black spot is a diffracted image of the crystal. The white circle at the centre is merely the shadow cast by a lead stop.

FIG. 8.—Contours of hæmoglobin molecules as calculated from X-ray analysis. The picture is equivalent to a poorly resolved microscopic image. The molecules lie with their greatest length at right angles to the plane of the picture. Their "waist" may be a spurious feature caused by inadequate resolving power.

FIG. 9.—Density of scattering matter in the hæmoglobin molecule projected on to a line.

principal features of the molecules, and to measure constants such as their weight, their shape, and their external dimensions.

The weight of protein molecules can be measured by means of the "Ultracentrifuge", an instrument invented by a Swedish scientist in the early twenties. In the ultracentrifuge a small quartz cell is filled with a solution of the protein and spun at the extraordinary rate of 1,000 revolutions *per second*. The protein molecules are thereby subjected to forces which are nearly a million times stronger than gravity. The ultracentrifuge works on the principle that the weight of small particles can be calculated from their rate of sinking in water. If the particles are very small, however, then their tendency to sink is counteracted by their trend to move hither and thither under the influence of heat and to distribute themselves uniformly throughout the liquid in which they are dissolved. As a result, the protein molecules will remain in suspension indefinitely if they are subjected to no stronger force than the gravitation of the earth. One way to make the molecules sink is to spin the solution so fast that the effect of their heat motion becomes small compared to the result of the powerful pull exercised by the centrifugal field. The rate of sinking of the protein molecules is then recorded photographically and used, together with certain other information, to calculate their molecular weight.

By making it possible for the first time to weigh protein molecules rapidly and accurately, the invention of the ultracentrifuge was a cornerstone in protein research and has added immeasurably to our knowledge of these vital substances.

Another field of protein physics was opened up when it was discovered that protein crystals can be made to give X-ray diffraction patterns which contain as much detail and are as clearly resolved as the patterns given by ordinary crystals like sugar or naphthalene, say. It should perhaps be explained that the analysis of X-ray diffraction effects from crystals, or X-ray analysis as it is called for short, enables the physicist to work out the sub-microscopic structure of matter. At the moment X-ray analysis is the most hopeful line of attack not only for measuring the external dimensions of protein molecules, but also for getting information about the distribution of matter within them.

Fig. 7 shows an X-ray diffraction photograph from a hæmoglobin crystal. From pictures like this one it was found that the hæmoglobin molecule resembles an egg-shaped body with a length of 6·4 mμ and an average width of 4·2 mμ. Fig. 8 is a contour map calculated directly from an X-ray diffraction photograph and gives an end-on view of the molecules. This picture gives only their outline without being sufficiently resolved to show up any significant detail, while Fig. 9 represents something in the nature of a cross-section through the molecules and gives an idea of the distribution of matter inside them. The four regularly spaced peaks convey the impression that the molecules consist of four roughly equal layers which are spaced 0·9 mμ apart. Each of the layers may consist of coiled polypeptide chains—perhaps resembling the globulin molecules in Pauling's picture (Fig. 5); this interpretation is still uncertain, however, and belongs to the realm of speculation.

X-ray analysis of protein crystals was only just starting on a sufficient scale when war broke out and many research projects were interrupted. The results so far obtained promise that it will be an important line of advance in the future.

Conclusion

The secret of the extraordinary versatility of proteins undoubtedly lies in their molecular architecture. Their capacity of protecting the organism from infection or of inducing chemical reactions appears to be based on the endless variety of different compositions and shapes which polypeptide chains can assume and which in turn give rise to a multitude of different patterns of chemically active groups on the surface of the protein molecules. At this moment the molecular structure of the globular proteins is still unknown. While it is unlikely that any single line of research or any startling new theory will suddenly reveal all that we desire to know, a concerted effort by scientists who specialise in different fields and can attack the problem independently from more than one angle has every chance of success. There is good hope that before very long new methods of research, together with refinements of existing experimental technique will gradually increase our general knowledge of proteins and lead to a more profound understanding of the micro-mechanism of Life.

[*Note.*—This article does not attempt to deal with all aspects of protein chemistry. For more detail the reader is referred to textbooks such as D. Jordan Lloyd and A. Shore, *Chemistry of the Proteins* and E. J. Cohn and J. T. Edsall, *Proteins, Amino-Acids and Peptides.*]

Self-sufficiency in Scientific Instruments

THE need for giving immediate and special consideration to the maintenance in Britain of the "master key" industries—"the small industries which make the tools with which the scientists work"—was urged upon the Government in a resolution passed at the end of an open meeting convened by the London Section of the British Association of Chemists and held at the Wigmore Hall on October 18. Several speakers went so far as to advocate that the Germans should be prevented from taking part in some of these industries after the war, and also to suggest that the importation of scientific instruments and the like should be prohibited except under licence.

The principal speaker was Mr. Norman Sheldon, A.R.C.S., F.R.I.C., who was followed by Lord Strabolgi, Col. W. A. Bristow, F.R.AE.S. and Dr. E. F. Armstrong, F.R.S. Mr. Sheldon began by referring to the historical background of the scientific instrument industries. The early scientists, he pointed out, made most of the apparatus they used with their own hands. It was about 200 years ago that manufacturers with suitable plant and skilled artisans began to take a serious interest in the production of scientific materials. The demand was extremely small and the work must have been undertaken more in the spirit of service to individual scientists than in any hope of making profit.

A German Monopoly

Mr. Sheldon traced the development of optical glass from the time of the Napoleonic wars—the finest optical glass was then made in London—up to 1939 when the Zeiss organisation was the largest of all optical instrument manufacturers. During the Franco-Prussian War Bismarek found that the German Army was depending on England for certain supplies, and he and his advisers realised that if Germany was to conquer the rest of Europe they must gain control of the scientific industries which they saw to be essential to success in any future war. As optical instruments appeared to be most important, the works already established by Zeiss, Abbe and Schott were merged into what was virtually a State-controlled and State-administered enterprise, and a world monopoly was quickly established. This support given by the German Government to the production of optical glass, scientific glassware of all kinds and optical instruments encouraged the scientific outlook and provided the equipment for research which led to the establishment of the great chemical industries which completed the picture of German scientific supremacy and made German science famous all over the world. "Within thirty years two great wars have been fought on European soil and they have been longer and more terrible than they should have been because we allowed one nation to become pre-eminent in the manufacture of every kind of scientific instrument and equipment and to develop the industries which follow from the activities of those engaged in making the great variety of instruments and chemicals used in scientific research."

During the last war, said Mr. Sheldon, the British Government nursed the scientific instrument and equipment industries and realised their importance. The Government was advised to take steps to ensure that certain industries were maintained in this country at all hazards and at any expense. Unfortunately the means chosen to protect the master key industries was a tariff. This measure failed in its purpose because it failed to enable these industries to secure all of the home market. Before the "Key Industry Duty" was applied, very large quantities of German goods were allowed into Britain, so that some British firms were brought to a standstill almost immediately and many never recovered. Mr. Sheldon stressed the small turn-over of these industries; he mentioned that each year 1 to 2000 Wheatstone Bridges are sold, with about 100 firms making them; the annual sales of Redwood Viscometers is about 144, and there are eight concerns producing them.

Mr. Sheldon urged that the master key industries should be protected in the same way that the dyestuffs industry was after the 1914-18 War. He asked for the prohibition of imports of master key material except under licence. "I ask for German production to be controlled or prohibited and all exports of these materials banned. Germany has had her opportunity and she abused it."

"If Great Britain is to adopt restrictions on imports of scientific equipment we must expect certain other countries to do the same, and rightly so. For strategic purposes certain countries among the Allied Nations must make themselves independent. This war has taught us that there must be three main centres of production, Great Britain, United States of America and Russia. Other countries such as France and Czechoslovakia can share in many sections without disturbing the equilibrium but for the sake of security and in order to ensure that research is on a satisfactory scale, Britain should lead in Europe and have a share in other world markets. I believe that there should be absolutely free and open exchange of information between the countries who do manufacture and that world markets should be so distributed that each recognised factory in the producing countries should have a reasonable output. In this way the duplication of vast expenditure on research could be saved and prices adjusted accordingly."

Col. Bristow referred to the need for modern scientific industry to work hand in hand with the scientific instrument makers. He instanced the importance of X-ray apparatus in steel making, and the part that instruments had played in the improvement of the efficiency of pneumatic tyres.

Lord Strabolgi spoke of the way that Germany had organised shortages of strategic materials and vital instruments by means of cartel agreements, and he recommended to his audience the two books *Germany's Master Plan* and *Patents for Hitler*.

Dr. E. F. Armstrong considered that Germany should be absolutely prohibited from taking part in some of these industries. He also disclosed the fact that the cost of rehabilitating the laboratories of Europe that have been wrecked and destroyed during the war will amount to £100,000,000.

Micro-organisms on Production

A SURVEY OF INDUSTRIAL FERMENTATIONS

G. COLMAN GREEN, B.Sc., F.R.I.C., A.M.I.Chem.E.

"THERE is no game, I think," writes Mr. Edward Shanks of cricket, "which has so many associations with other things—with the village green, and the village inn and the village itself, with weather and landscape as well as with Bradman at Lords and Hobbs at the Oval and Grace everywhere". So it is on an international scale with industrial fermentations. Their roots ramify into the sugar estates and factories of Manila and Barbadoes, and the rum distilleries of Cuba, into the Corn Belt of the Americas, the potato and sugar-beet areas of Europe, and the vineyards of Champagne. They link with the lacquer on the latest car model, the silk-wear of the elegant lady stepping from it, the fuel mixture in the tank, the fruit pastille which the owner might be (less elegantly) sucking, the cheese, the pickle, the plastic knife-handles and beakers, the very bread itself packed in the picnic basket at the rear. For at some point in the manufacture of all these things—and more beside—microbiological processes have intervened to provide either the organism itself—as, for example, yeast for the bread—or some ingredient or intermediate such as ethyl alcohol, butyl alcohol, acetone, acetic acid, citric acid, and tartaric acid. These substances and their derivatives are of very great importance in modern industry and there may be named in addition glycerine, lactic acid, sorbitol and gluconic acid as products of industrial fermentations.

The organisms employed to produce these commodities range from the unicellular rod-like bacteria through the ellipsoidal unicellular yeasts to the morphologically more complex moulds. It is the purpose of this survey not to consider the biochemistry of these organisms and the mechanism of the reactions involved, concerning which much has been written since the time of Pasteur and will continue to be written, but to consider the much less generally appreciated industrial implications, applications and world-wide repercussions of these microbiological processes. Where relevant it is proposed to lay particular emphasis upon the causes and consequences of the search for raw material and to observe the effects that these processes have had in disturbing established industries or creating new ones.

Among these industrial fermentations the production of ethyl alcohol takes pride of place by virtue of the antiquity both of its manufacture and its utilisation. At the outset it is necessary to distinguish between industrial alcohol, power alcohol and potable alcohol. The last is beverage alcohol, as its name implies, and includes such spiritous liquors as whisky, gin, rum and brandy, which are characterised by their particular flavours and aromas. Their strength in terms of alcohol content lies rather less than midway between beer and industrial alcohol. By comparison, industrial and power alcohol are "neutral" spirits—that is, their aroma and flavour are negligible and generally unimportant. The chief characteristic of these latter is their high ethyl alcohol content, in which respect they are also distinguishable the one from the other. Industrial alcohol contains 94·7% ethyl alcohol, the balance being almost entirely water, as there are only traces of other substances, and this is the highest strength of spirit attainable by ordinary rectification methods. Alcohol and water in these proportions form a constant boiling or azeotropic mixture and are only further separable by special methods. Alcohol of this strength is that which is used, perhaps diluted with water or denatured as necessary, as a raw material or solvent in industry. On account of the 5·3% of water which it still contains, however, it is immiscible with petrol and therefore in order to produce a petrol-alcohol fuel mixture, this alcohol must be dehydrated to give power alcohol. A number of interesting methods for accomplishing this have become available in recent years, but will not be discussed further here.

The preparation of alcoholic beverages in one form or another has been known to man for so long a time that its origins are lost in the most remote recesses of antiquity. The art has been practised throughout the world except in those areas which are unsuitable as to climatic conditions or are entirely lacking in raw materials. The raw materials used are rich in the simple fermentable sugars or, like the starchy materials, are capable of being previously degraded to simple sugars, usually by enzyme action as in the well-known brewery mashing operation. The raw materials available vary with the region of the world, and the yields obtainable from various sources are given in Table I. It will be seen that the best yields per ton are not necessarily the best yields per acre. Moreover, the table does not take cognisance of other marketable parts of the crop yielded by the area under cultivation. For example, blackstrap molasses contains about $\frac{1}{4}$th of the sugar produced per acre, the remaining $\frac{3}{4}$ ths having gone as raw sugar to the refineries; even the residual exhausted cane is used as fuel for the factory boilers or is used in the manufacture of fibre board.

The raw materials are the principal factors which confer on the resultant beverage the characteristic flavour and aroma. Thus rum is obtained from cane-sugar products—now almost exclusively from the molasses—indigenous to the West Indies. The grape has long been the source of the European brandies. In early Britain honey from the native wild bee was used for mead until ousted by the cultivation of the grape which became centred upon the great monastic houses. With the dissolution of the latter grape cultivation faded away and only the name of the former site remains as in "The Vineyard" at Ely and elsewhere. It is conceivable that, with so inclement a climate as is experienced in this country, grape cultivation could not be a commercial proposition and could only flourish where labour was free and plentiful and where the periodical failure of the crop could not bring economic disaster. Subsequently, a great trade in wines and spirits developed with the continent and it was not long before the ruling powers found these imports a rich source of revenue. The usual consequence of rising prices following the application of taxes of increasing severity promoted the

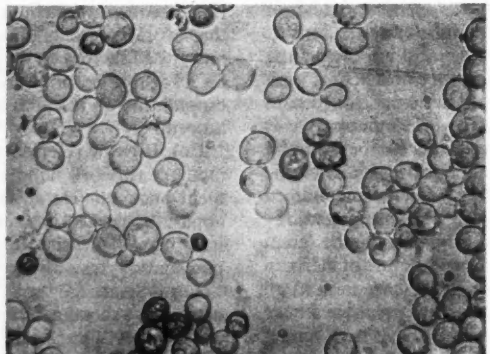


FIG. 1.—*Saccharomyces cerevisiae*. Living yeast cells. Magnification × 700. A number of the yeast cells continue to proliferate by "budding". (*Photomicrograph by courtesy of The Distillers Company Ltd.*).

development of whisky production, which was already established in Ireland and Scotland, from native grown grain.

A Traditional Art

The nature of alcoholic fermentation was, of course, not in the least understood and the preparation of alcoholic liquors remained an "art" until the time of Pasteur. The essential operations were empirically determined and controlled and must have inevitably resulted in a great variability in the product. The alcoholic fermentation was conducted along the traditional lines of mashing such milled grain as might be available with a varying proportion of malted barley and pitching the resulting wort with barm collected from a previous brew. A portion of the barm was thus set aside from each brew in order to start fermentation in the next. The beer or fermented wort was now ready for the separation of the alcohol along with other volatile constituents which confer the flavour and aroma, and this was accomplished by distillation. Knowledge of and skill in the use of stills, albeit simple and of primitive types, is very ancient and was well developed by the Middle Ages when the product obtained by distilling alcoholic beverages was known as *aqua vitae*.

The recognition that alcoholic liquors had other applications than that of cheering the heart of man was an early one. The power of these liquors to dissolve substances either not soluble in water at all or soluble to a lesser degree than in the alcoholic liquor was the first property to be distinguished. The ancients knew, of course, that wine would dissolve substances from various plants and the knowledge was put to considerable use by them in the way of ridding themselves of indisposition or of their enemies. These preparations survive in the tinctures of modern pharmacy, a famous and immediate progenitor of which is the laudanum of Sydenham, consisting of opium (the active principle of which is morphine) dissolved in Canary Wine and flavoured with clove, saffron and cinnamon.

Parallel with the use of alcoholic liquors in pharmacy there developed their use in the preparation of perfumes, the pre-eminence of French perfumery being partly ascribed to the pleasant odour of the spirit used, which was derived from off-quality brandy.

Development of Industrial Use

It was not, however, until the rise of chemistry as an exact science towards the end of the 18th century that the importance of ethyl alcohol both as a solvent and as a raw material or process chemical in the manufacture of other materials became fully appreciated. As has been pointed out, it was grain alcohol which was available in this country for the first industrial uses and the Government which had long since found alcoholic liquors a reliable and extensive source of revenue had no intention to discriminate in favour of industrial use or any other use which would prejudice such revenue.

TABLE I

YIELDS OF 99·5% ALCOHOL FROM THE MORE IMPORTANT RAW MATERIALS (IN U.S. GALLONS)

	Raw Material	*per short ton*	*per acre*
1	Wheat	85·0	33·0
2	Maize	84·0	88·8
3	Barley	79·2	47·9
4	Blackstrap	70·4	45·0
5	Potatoes	22·9	178·0
6	Sugar Beet	22·1	287·0

So high was the cost of alcohol in the early part of the 19th century that it was necessary to make every effort to avoid its industrial use in this country. For example, in 1813 Sertürner first isolated morphine, the active principle of opium, and considerable quantities of alcohol were necessary as a selective solvent. William Gregory, Professor of Chemistry at the University of Edinburgh, was led in 1831 to evolve a process which avoided the use of this costly alcohol, and as a result he was able to produce pure morphine hydrochloride at the same cost, dose for dose, as the traditional and variably potent laudanum. Gregory was thus able to add a most important weapon to the armoury of the physician. Again, the cost of producing quinine was substantially reduced as a consequence of a process devised and patented by E. Herring in 1853 and worked by him in association with T. Whiffen at Battersea, the essential feature of which was the avoidance of the use of alcohol. In other cases there was not so happy an outcome.

The obstinacy of the Government in declining to permit the use of duty-free ethyl alcohol for *bona fide* industrial use was undoubtedly an important factor, later in the 19th century, in the strangling of the dyestuffs industry which was established following Sir William Perkin's discovery of the first aniline dye. In the manufacture of these dyes alcohol is required in substantial quantities both as a solvent and as an intermediate material entering into various reactions. The cheaper continental alcohol, the early establishment of schools devoted entirely to the teaching of and research in chemistry, and the greater enterprise and farsightedness of their industrialists led to the establishment of the great German dyestuffs and pharmaceutical industry, whereas no comparable development took place in this, the country of origin, as we found to our cost when the 1914 war broke out. As the story of the evolution of industrial fermentations becomes unfolded this situation will be found to repeat itself all too often.

Nevertheless, as a consequence of pressure from industry, the British Government was the first to make *denatured* alcohol available for industry free of duty. The necessary legislation was carried through in 1855 and, strangely enough, it was not until 1906 that similar steps were taken in U.S.A. The object of denaturing was to make the ethyl alcohol quite unsuitable for use as a beverage and this was attained by the addition of 10% of crude methyl alcohol. During the present century the authorities have taken an increasingly enlightened view and where the presence of methyl alcohol might be deleterious in the operation for which the alcohol is intended they will consider proposals for the use of an alternative inert denaturant. A simple example of the application of this concession is the denaturing of absolute alcohol with a proportion of petrol when it is later to be used for admixture with petrol as a fuel.

Pasteur's Classic Researches

At about the time that this important legislation was carried through two other developments were occurring which were destined to have far-reaching effects on the getting of ethyl alcohol. The first development was Louis Pasteur's discovery of the nature of alcoholic fermentation which he communicated to the Academy of Sciences in December 1857.

He it was who, in the face of bitter opposition from Liebig on the one hand and Pouchet and his school on the other, proved that fermentation was not a consequence of the decomposition of animal and vegetable matter, nor the result of spontaneous generation of organisms within the medium, but of infection with organisms present in the non-sterile air with which the medium came into contact. Pasteur's classical discoveries in pure bacteriology had profound effects on the fermentation industries and paved the way for pure culture of the organisms involved as well as the prevention of infection by unwanted organisms of the media being used. He established the proportion of alcohol and carbon dioxide which could be consistently obtained in properly controlled conditions from a given weight of sugar and observed the production of glycerol in small quantity the origin of which he was unable to explain. Perhaps most important of all he showed that the maximum yields of alcohol could only be obtained by the exclusion of air from the fermenting vessel i.e. by anaerobic fermentation and that if air were not

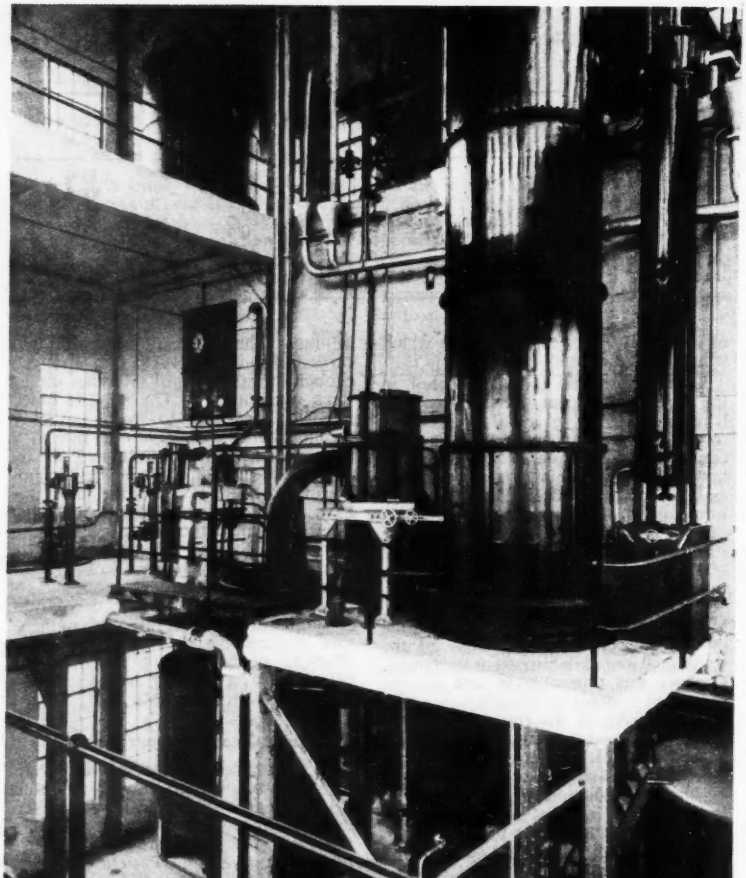


FIG. 2.—A continuous alcohol still. This is a difficult photographic subject as the installation extends through four floor-levels, of which the second, third and fourth are seen. Left bottom centre is the beer or stripping column to which wash is fed. Weak alcohol vapour passes from the top of the beer-column through the large-diameter curved pipe to the bottom of the copper rectifying column to be seen standing on the central concrete floor. On the same floor to the left are the "safes" where strength of spirit and rate of flow are indicated. The rivets in the rectifying column indicate the position of the horizontal plates or trays fitted with bubble-caps by means of which ascending vapour is "scrubbed" by descending liquid. (*Photograph by courtesy of Solvent Products Ltd.*).

excluded yeast growth took place, to the detriment of alcohol formation. This important differentiation between two contrasting environments led, on the one hand, to a more efficient production of alcohol by already existing distilleries and, on the other hand, through an industrial pure culture technique devised by Hansen in Denmark, to the development of the air-yeast industry. In the latter, wort is first inoculated with suitable quantities of yeast after which large quantities of clean air are blown into it. This results in the repression (but not total abolition) of alcohol production and great increase in growth of the yeast. It is by this method that pure culture baker's yeast is produced to-day. Pasteur thus distinguished between the two extremes of aerobic and anaerobic fermentation, yeast growth preponderating in the former with very little alcohol production, and alcohol production preponderating in the latter with very little yeast growth. It will be seen later how important is this question of air supply or its exclusion in other industrial fermentations.

Coffey's Still

The second important development was the invention of a still capable of continuous operation by Aeneas Coffey, Inspector General of Excise in Ireland, who left the Service to develop his invention. Previously distillation had been carried out in whisky stills consisting of a pot or boiling vessel surmounted by a rectifying column and condenser, the operation being batchwise, i.e. a charge was placed in the pot from which the alcohol was distilled, after which the plant was closed down whilst the "slops" were emptied from the pot and a fresh charge of "beer" or "wash" was introduced. In Coffey's still "beer" was continuously introduced to the top plate, but one of a beer—or stripping—column and steam was introduced at the bottom of the column. By the time the beer had flowed downwards over a series of superimposed perforated plates the alcohol was completely volatilised and conducted from the top of the beer-column to a rectifying column. Meanwhile the exhausted beer or slops was drawn off continuously from the bottom of the column and passed to the sewer. The saving in steam, labour and overheads by the introduction of this type of still was a potent factor in reducing the cost of alcohol manufacture and increasing its availability to industry.

Until towards the end of the 19th century grain was the principal source of alcohol production and carried with it intrinsic commercial disadvantages. Not only is it subject to fluctuations in price according to the abundance or otherwise of the world's harvests, but, further, the alcohol industry competes in the face of huge demands for it for human food and animal feed. A great increase in the standard of living has taken place in the past 75 years which has followed on extensive technological developments. With it a vast sugar industry has been established, the extent and prosperity of which has been primarily due to the development of the multi-effect vacuum evaporator.

Alcohol from Molasses

Parallel with the production of increasingly great quantities of sugar was the production of a proportional amount of the uncrystallizable residue known in this country as "molasses" and in America as "blackstrap". The weight of molasses produced is roughly one-fifth the weight of cane-sugar produced, and the disposal of this residue would be a difficult problem were it not for the fact that, by virtue of a sugar content of about 50% by weight and a satisfactory content of mineral salts required by yeast, it can, with very little treatment, be used as a most satisfactory (and by far the cheapest) raw material for the manufacture of alcohol or yeast.

Practically the whole of the alcohol produced in recent years in this country for industrial purposes or fuel has been derived from imported cane-sugar molasses supplemented with refinery molasses manufactured here from imported raw

sugars. There has also been a more limited quantity of molasses arising from the subsidised beet-sugar growing industry. This latter was established by Dutch interests at Cantley in Norfolk before the 1914-18 war, and has in the meantime been encouraged financially and otherwise, to the satisfaction of the farming community who in the depressed period found sugar-beet the one profitable crop. It has been reported that the home beet-sugar industry has provided the whole of the domestic sugar ration in this present war and the proportional amount of molasses produced from this industry must have proved invaluable for the production of baker's yeast, for which purpose beet molasses is preferred to cane molasses on account of its possession of additional yeast-growth nutrients.

In the middle 1930's in the U.S.A. by comparison, three-quarters of the industrial alcohol produced was by fermentation of molasses. Since the war began many other sources have had to be mobilised to meet the extraordinary demand for ethyl alcohol for synthetic rubber production, and this will be referred to later. In the meantime it is of interest to examine Table II to see the recent distribution of alcohol between the various sources.

The European countries have developed sugar-beet and beet-sugar industries from the time of the British blockade of France during the Napoleonic wars, when sugar ceased to be imported into that country from her West Indian possessions. So widely has the sugar-beet become cultivated in the central European states and so flexible and indulgent have been their excise laws that industrial alcohol is actually distilled on the farms from the sugar-beet juice direct, without a sugar industry intervening. On the continent, too, large amounts of alcohol are produced from potatoes which could not be used in this country on account of the greater cost of producing the crop. France, in normal times, produces some 99 million gallons of alcohol per annum, the derivation of which from various sources is shown in Table III.

The production of cane molasses being largely confined to the islands of the Carribean and China Seas, its transport presents a great problem even in peace time, bringing into existence fleets of tankers equipped with pumps capable of dealing with such viscous, treacly liquid. Because of the vast sea-movement of this material, transport charges upon which must be kept low if alcohol and yeast are to be made from it cheaply, the molasses—alcohol distilleries are almost entirely confined to the worlds seaports. In this country, because of its special geographical circumstances, the distilleries are sited in both West and East coast estuarine ports. In the U.S.A. the molasses—alcohol distilleries are mainly on the East coast and on the Gulf of Mexico, to be as near as possible to the Carribean source, and these Atlantic and Gulf states account for 77·5% of the American industrial alcohol output. There is a subsidary concentration on the West coast to receive molasses ex-

TABLE II

SOURCE OF U.S.A. INDUSTRIAL ALCOHOL IN 1937 AND IN 1943 (PERCENTAGE OF TOTAL OUTPUT)

Source	1943	1937
Synthetic and miscellaneous	14·3	15·9
Molasses fermentation	22·9	75·7
Grain fermentation:		
(a) industrial alcohol distilleries	9·5	8·4
(b) former beverage distilleries	41·2	
(c) redistillation of "high wines"	12·1	
	100·0	100·0

TABLE III

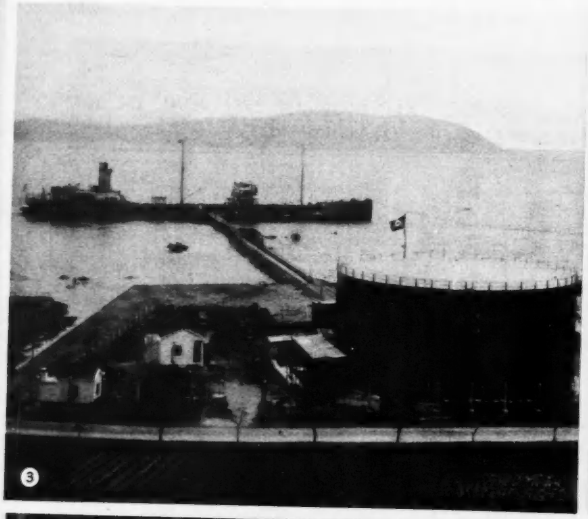
FRENCH ALCOHOL OUTPUT AND ITS VARIOUS SOURCES

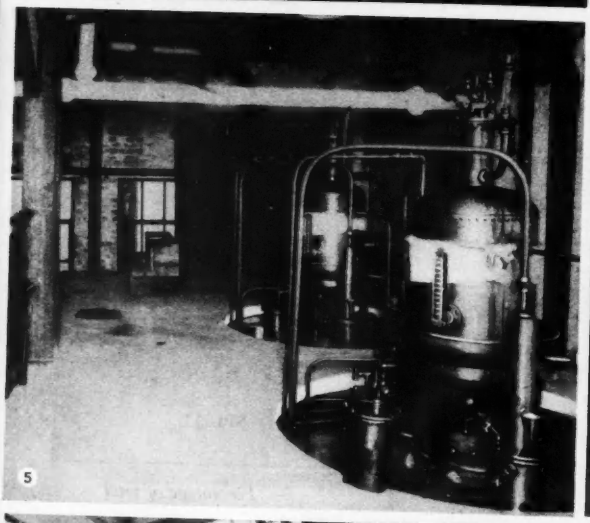
	Source of alcohol	*Percentage of total output*
1	292 beet alcohol factories	66·6
2	Wine and cider (sours, lees and waste)	23·4
3	Molasses alcohol factories	9·3
4	Synthetic alcohol	0·7
5	Grain (mainly gin)	(less than 1/10 of 1%)

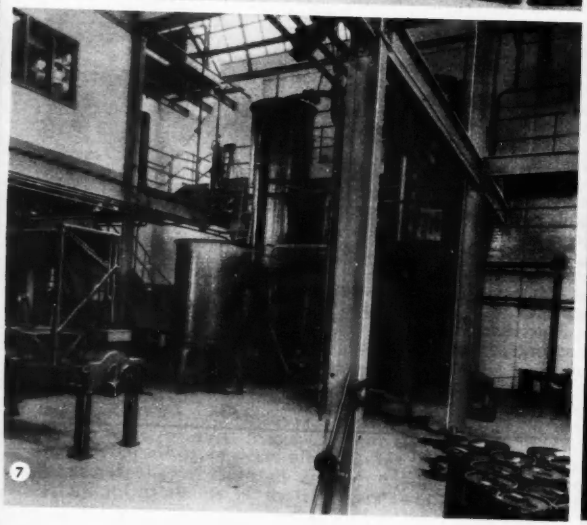
TABLE IV

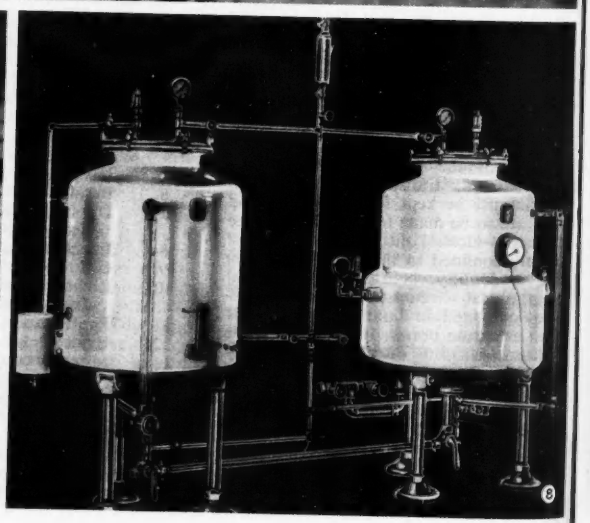
USES OF INDUSTRIAL METHYLATED SPIRIT IN 1938-39

	Uses	*Percentage of total*
1	Varnishes, stains, lacquers, paints, enamels, polishes, etc.	57·0
2	Soap, toilet articles and perfumery	9·1
3	Oil-cloths, leather-cloths, etc.	4·8
4	Anæsthetics, alkaloids, fine chemicals, medicinal extracts, etc.	4·2
5	Hospitals, asylums, infirmaries	3·4
6	Pyridinised spirit for sale	3·2
7	Dyestuffs, textile printing, dyeing, laundering, cleaning, etc.	3·1
8	Inks, printing, electro-typing, etc.	3·1
9	Celluloid, xylonite, collodion	2·4
10	Embrocations, surgical dressings, capsules, disinfectants	2·2
11	Photographic materials and processes	1·5
12	Explosives, fireworks, matches	0·7
13	Miscellaneous	5·3
		100·0









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ported from the Philippines with an output of 2·1% of the total. By contrast, there is another group of distilleries hundreds of miles inland which are adjacent to the great Corn Belt, from which they draw their raw material, producing 20·4% of the total industrial alcohol.

In the United Kingdom in the fiscal year 1938-39, 19 million proof gallons (*) of duty-free, pure ethyl alcohol were used in the "arts and manufactures", an official phrase which embraces such uses as the extracting of certain drugs, the manufacture of fine chemicals, the manufacture of acetic acid destined for the production of vinegar and—*very* important—for the production of cellulose acetate for artificial silk. In addition, 8·1 million proof gallons of *methylated* spirit were used and Table IV has been constructed from official sources to show who were the users of this methylated spirit.

The most striking feature is the overwhelmingly great proportion, amounting to over 4½ million proof gallons equivalent to 57% of the total output, which was utilised by the firms manufacturing varnishes, stains, lacquers, paints, enamels and polishes. The second largest group of users—the soap, toilet articles and perfumery industry—falls far, far behind with an annual consumption of only just over 9.1% of the total. The table, however, has its limitations and it does not bring out, for example, the degree of importance of alcohol as a raw material in the manufacture of the anæsthetics such as ether, chloroform (acetone is more often used), or ethyl chloride; of such solvents as ethyl acetate; and of acetaldehyde which has lately taken on a fresh importance in connection with the manufacture of butadiene, an intermediate in the manufacture of synthetic rubber.

In U.S.A., prior to 1936, the biggest individual consumers were the manufacturers of anti-freeze solutions for automobiles. The war has brought about a remarkable change and this change will be referred to later. As American industry has become increasingly adjusted to the war effort the distribution of consumption has fluctuated and the approximate position in 1943 was as is given in Table V. No alcohol was used for synthetic rubber prior to 1943, whilst "lease-lend" was zero prior to 1940 and "direct military" was negligible. The chief military use is in the manufacture of smokeless powders, of which the British type is cordite, requiring up to ⅓rd lb. of alcohol per lb. of explosive. Much of this alcohol is, however, recoverable for re-use.

(To be continued).

*A British Fiscal Proof Gallon is roughly equivalent to 6/10ths of an Imperial gallon of 95% alcohol.

TABLE V

APPROXIMATE AMERICAN USES OF ALCOHOL IN 1943

	Use	*Percentage of total*
1	Chemical Manufacturing	28·0
2	Direct Military (i.e. explosives)	22·0
3	Lease-Lend	13·0
4	Anti-freeze	10·0
5	Synthetic rubber	8·0
6	All other uses	19·0
		100·0

FIG. 3.—A typical molasses tanker discharging into a shore storage tank. The white armoured-hose, slung from the derrick over the ship's side, connecting the ship's pumps with the pipe-line running beneath the jetty to the shore tank, is just discernible. (*Photograph by courtesy of The United Molasses Company, Ltd.*).

FIG. 4.—A roof truss view of six steel 55,000 galls. molasses fermentation tanks. (*Photograph by courtesy of Solvent Products Ltd.*).

FIGS. 5 and 6.—Upper and lower floor views of so-called 'yeast-machines' of the Magnet type which are widely in use in British molasses alcohol distilleries. The small upper tinned-copper vessel is innoculated with a laboratory yeast culture. After the yeast has suitably multiplied it is blown with sterile air into sterile wash in the lower larger vessel where it is aerated intensely. This culture is blown over into molasses wash in the large steel "bub-tun" on the left for final aerobic growth, after which the "bub" is transferred, under Excise supervision, to the fermenting vessels shown in Fig. 3. (*Photograph by courtesy of Solvent Products Ltd.*).

FIG. 7.—Yeast production plant. Yeast is grown under highly aerobic conditions in the cylindrical copper vessels. It is subsequently separated from the wash, firstly with the centrifugal separator (left background) and finally in a filter press similar to the one shown on the left. Note that the building is lined with glazed brick to maintain cleanliness and to help in keeping down infection. (*Photograph by courtesy of The Distillers Company, Ltd.*).

FIG. 8.—A glass-lined propagator of the type much favoured in the United States especially for the manufacture of lager beers. Wort is sterilised by the application of steam to the jacket of the right-hand vessel, after which it is transferred to the left-hand vessel which is the actual propagator. The properly attemperated, aerated, sterile wort is then "seeded" with a laboratory culture of pure yeast via the cock in the side of the propagator near the small vessel (which is a water-seal) at the extreme left. (*Photograph by courtesy of Enamelled Metal Products Corporation* (1933) *Ltd.*).

Science in India

PROFESSOR HILL'S MESSEL LECTURE

SCIENCE IN INDIA was the subject chosen by Professor A. V. Hill for the lecture he gave, as Messel Medallist, to the resumed annual meeting of the Society of Chemical Industry held at the Royal Institution on October 13. By a happy coincidence the members of the official mission of Indian scientists were able to attend, and it was fitting that one of them, Sir Shanti Bhatnagar, moved the vote of thanks at the end of the lecture.

After speaking of the circumstances that surrounded his recent visit to India and the warmth of his reception there, Professor Hill spoke of the important part that science could play in the development of that country.

There is, he said, a real interest in science among thoughtful people in India, and a widespread conviction that science and the scientific method, deliberately and resolutely applied to national development, may be the saving of their country. They have seen the example of other countries, and have been particularly impressed by what has happened so quickly in Russia; though they realize that Russian methods are not applicable wholesale to India. They know perfectly well, also, that scientific development, in the present state of Indian resources, is only possible by co-operation; and sensible people want to co-operate—with each other, with us, and with the rest of the world. It is well understood that science, more than any other subject, is international in its scope, method and outlook. If people can collaborate in anything at all, they can surely do so in scientific research; and there is, in fact, very little isolationism among Indian scientists—that swindle has been shown up by world events. Moreover, there is hope that by working together in scientific research, collaboration can gradually be achieved in all the other things that follow research, by which knowledge is applied to men's urgent practical needs for health and comfort. A close and friendly partnership between the scientists, the doctors, and the engineers of Britain and India might very well succeed in repairing the damage done by treating the problems of India far too long as mainly political ones, instead of chiefly concerned with the betterment of the life of its people, suggested Professor Hill.

Of the progress of Indian science in the recent years, Professor Hill said it gave grounds for hope rather than dejection. Continually his Indian scientific friends talked bitterly or sadly about the slowness of their progress, the poverty of their universities and institutions, the lowness of their salaries, the under-staffing of their laboratories, the shortage of proper equipment, and particularly the lack of contact with the outside scientific world. "Most of this is true when measured on the absolute scale" remarked the lecturer "but I begged them to remember that in the last 25 years Indian scientific progress has, in fact, been greater than in the whole of previous history."

"It is true enough that only a beginning has been made. The universities and medical colleges are mostly very poor, the latter being mainly staffed by part-time teachers chiefly occupied in practising medicine to earn a living; many laboratories, particularly on the biological side, are under-staffed and ill-equipped; endowments are few and far between; and standards, on the whole, are low. Of the population over five years of age only 20% are literate, of men 31%, of women only 8%; and of all these only about one tenth are literate in English, which is the language of science. Great plans indeed for the improvement of education are being considered, under the inspiration of Mr. John Sargent, Educational Commissioner with the Government of India; but these are bound to take many years to be completed, owing to present lack of teachers, buildings, and equipment."

"There is a common idea that the Indian mind tends rather to dialectic than experiment, to literary, legal, or philosophical studies than to practical science or technology. I doubt if this tendency, so far as it exists, is more than an unfortunate accident, due partly to the fact that such studies are cheap and easy, requiring nothing more than lecture-room and books, while practical science and technology are costly in laboratories and equipment. Recent experience in training youths for the technical branches of the Indian Forces has shown astonishingly satisfactory results, and a visit to such places as the Meteorological Observatory at Delhi, or the Tata Steel Works at Jamshedpur, proves that Indian scientists, artificers and operatives can show a high degree of skill, dexterity and workmanship. In fact, one of the greatest needs of Indian science and technology is of better opportunities, from childhood onwards, for practical and technical training and experience."

Complex of Biological Problems

"The fundamental problems, however, of India", he continued, "are not really physical, chemical, or technological, but a complex of biological ones referring to population, health, nutrition, and agriculture. "It is the more regrettable, therefore, that the biological sciences, on the whole, are so weak and that provision for teaching and research in them is generally so deficient. The tendency, at present, in India, is to think of progress and development mainly in terms of industry and its needs, requiring chiefly physics, chemistry, engineering, and metallurgy as their basis. We now know that the future developments of science will lie, not perhaps in the purely biological field, but largely in that where the biological and the physical sciences meet and react with one another. The first of India's scientific needs is to strengthen and expand education and research in the biological sciences, in medicine and its associated subjects, in physiology and biochemistry, in zoology, botany, and genetics, and in all the applications of biology to fisheries, agriculture, public health, pest control, animal and plant diseases, forestry, and so on."

In emphasizing the importance of the biological sciences to India he would not underestimate the value of physics, chemistry, metallurgy, and engineering; for progressive biology in these days depends very largely on the tools and methods of physical science; and, moreover, large-scale industry based on these has to provide the means and

resources, the tools and equipment, the chemicals and the transport, which make a progressive development possible in agriculture and medicine. All he wanted to urge is that India's fundamental needs are in the biological field and must be so regarded if a true picture is to be formed.

In planning for the development of India, one of the chief requirements will be of more accurate information of what Indian resources actually are: resources of minerals, plants, and animals; of water and water-power; of labour; and of trained ability. For this purpose the Geological, the Zoological, and the Botanical Surveys should be greatly strengthened and improved, and a number of new surveys or assessments instituted. At present there is no national register of scientific and technical personnel comparable with our Central Register here, but the National Institute of Sciences has now started to construct one.

The importance of scientific societies in India should be even greater than in Britain, said Professor Hill, because of the greater tendency for everything to come under the Government—"and governments everywhere need to be watched, guided and criticised by independent agencies and people." An adequate endowment of the learned societies could do more for Indian sciences than any comparable expenditure in other ways.

As an account of Indian scientific societies Professor Hill recommended to his audience the article by Sir Lewis Fermor which appeared in DISCOVERY (August, 1943).

"As regards distances in India, after the war we may look for a wide extension of air travel. Far better than a government subsidy to air lines would be an assured pay load by a gift to learned societies of a very substantial mileage of free air-travel for their members. Science has made flying possible, the boot should now be on the other leg and flying should help to advance science by providing easier intercourse between scientific men."

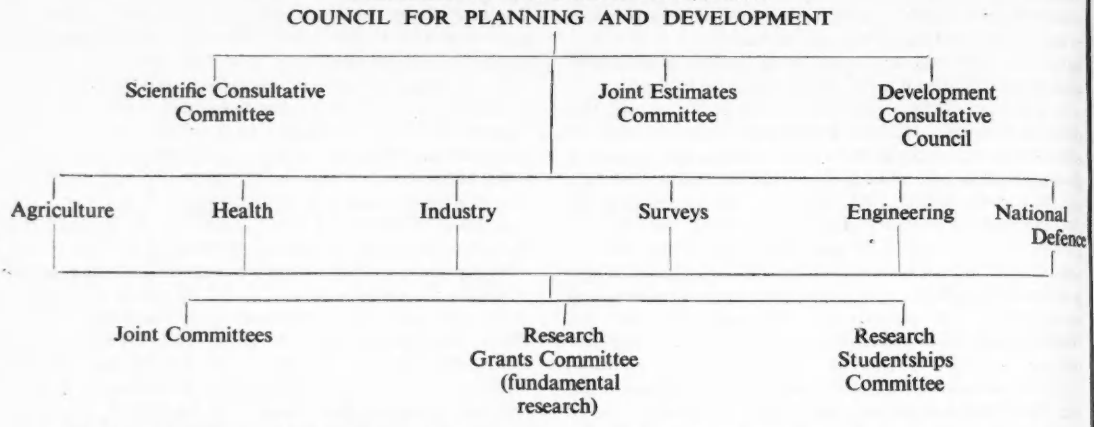
"If Indian science is to make the contribution it could to national progress it is imperative that industry should play its full part. Indian industrialists are not unmindful of what science can do for them; they take, for example, a very special interest in the work of the Board of Scientific and Industrial Research. But on the whole they tend rather to expect other people, particularly the Government, to supply the science while they supply the exploitation of it. There are few examples, as yet, of real research done by industrial firms in their own laboratories; and there are very few examples of endowments for research, in universities and elsewhere, provided by Indian industry. The relative lack of understanding of the importance of pure science provides a certain danger, viz., that special value might still be attached, by those who dominate policy, to applied rather than to pure science in universities and research institutions. The Tata organisation has been different from the majority in this respect."

"In this country, in addition to many research laboratories in individual firms, there are about twenty-five Research Associations working co-operatively for industry in connexion with the Department of Scientific and Industrial Research. In India the Board of Scientific and Industrial Research has not yet established such joint Associations, but a certain number do in fact exist; they are maintained, not by a levy on industry assisted by a grant from Government, but by a cess on the raw product. The laboratory at Bombay of the Indian Central Cotton Committee is a good example of this; there are other similar organisations for research on lac and jute, and there may soon be one for sugar. Provision, moreover, has recently been made by the Government for national laboratories to be established under the Board of Scientific and Industrial Research for research in Physics, Chemistry, Metallurgy, Fuel, and Glass; to this development the Tata organisation has made a substantial contribution."

"The laboratories of the B.S.I.R. at Delhi are mainly occupied at present in special chemical problems related either to the use of raw materials (for the manufacture, for example, of plastics) or to the special needs of the war. Some very successful processes have been worked out there, which are now being developed industrially. Recently founded, there is now an excellent Institute of Chemical Technology at Bombay, attached to the University, while the new Ordnance Laboratories at Cawnpore are undertaking important work in a great variety of subjects—even to making the first good surgical instruments ever to be manufactured in India and equipment for producing beer for the troops! Propellent has long been made in India and there is now a modern plant for the manufacture of high-explosive. Plans are in contemplation for the manufacture of food-yeast on a large scale; there is great need in India of high-class protein and *B*-vitamins for addition to a diet of low-grade cereals. Chemical industry has made a good start, but I gather that there is till rather little understanding of really large-scale chemical processes. There is great need, therefore—and the same is true of other industries—to send scientific and technical people abroad for high-class laboratory and works experience. It would certainly be wise for British industry to offer facilities for this purpose. If India is not to have full co-operation with us she will certainly turn to America—and in spite of hard words about "British Imperialists" she would really rather co-operate with us. Moreover, a sterling balance which by the end of this year will probably be about £1000 million will mean a big demand for British capital goods; those will require trained hands and brains to use them. I have no doubt, myself, of the wisdom of offering any help we can for the higher training of Indian scientists and technicians. A good start has been made with the 'Bevin boys,' but the plan needs extending to the higher grades."

Professor Hill then spoke of the manner whereby research financed by the Central Government of India comes under many departments. At present there is nothing like Britain's central organisation consisting of three Research Councils under the Lord President. Probably the new member of the Viceroy's Executive Council for Planning and Development would take this matter in hand.

"Before I end, let me give you the outline of a plan—an imaginary plan at present—for research in India in connexion with national development. No doubt all kinds of difficulties will be found, all kinds of reasons discovered why changes should not be made—but we are well used to that here. Under the Member for Planning and Development, a system of six Research Boards would be set up, dealing, respectively, with Agriculture, Health, Industry, Surveys and Natural Resources, Engineering,



A PLAN FOR THE ORGANISATION OF INDIAN SCIENTIFIC RESEARCH AND DEVELOPMENT

and National Defence. Each Board would have, as Chairman, not a minister or politician, but an eminent scientist or professional man, of the kind we appoint here as chairman of one of our research councils under the Lord President. Members of the boards would be scientific or practical men in their respective fields and there would be a certain number of members representing the development interests to be referred to later on. The work of the six boards would be co-ordinated by common membership."

In each subject there would be a Director of Research, who would be a scientific man of good standing. He would be secretary and principal executive officer of his own board and a member of each of the other boards. He would be responsible for directing, organizing, initiating, and co-ordinating research on a nation-wide scale in his field. Each board would have a number of committees dealing with various aspects of its work and joint committees would be set up between boards. Each board would allocate grants in its own field, for specific researches to be carried out in any institution in India. A Research Grants Committee would be established jointly between the different boards, to award grants to university and other laboratories throughout India for the encouragement of fundamental scientific research. If a University Grants Committee were set up, these general research grants would be given in consultation with it. A Research Studentships Committee would be appointed jointly between the different boards, to consider applications for research studentships, particularly by young workers of proved ability desiring to gain further experience by research abroad. Each Director of Research would prepare estimates for his Board which, after discussion and approval, would be submitted to the Member for Planning and Development. A Joint Estimates Committee, under the chairmanship of the Minister, would compare and co-ordinate the different estimates before submission to the Finance Department. After estimates had been approved, each board would be able freely to spend the funds at its disposal without further application or interference. To advise the Member for Planning and Development on general scientific policy, and on special matters submitted to it, a Scientific Consultative Committee would be appointed consisting of the six Directors of Research and of six distinguished scientists, one in each field; it would bear a close analogy to the War Cabinet Scientific Advisory Committee here.

"In addition to all this, it would be well to set up, in the 'user' departments, Development or Improvement Councils to apply the results of research directly to the various practical problems affected by it. Joint *ex-officio* membership, either way, of an Improvement Council and its corresponding Research Board (or Boards) would ensure, on the one hand, that the results of research were fully known to those who had to apply it, and, on the other, that those who had to do the research were kept amply aware of the practical needs. In order to ensure that development as well as research was well looked after and co-ordinated at a high level, it would probably be wise to set up, under the Member for Planning and Development, an opposite number to the Scientific Consultative Committee, namely, a Development Consultative Council. This Council would not interfere with the executive responsibility of departments to deal with their separate projects of development; it would ensure that attention was kept focused on those various projects, that the Member for Planning and Development was kept properly informed of them, and that they were welded together into a consistent and well-balanced plan."

"To Indian scientific men, well brought up in the pessimistic faith that nothing whatever will really get done, such a plan would seem too good to be true. But a new spirit is abroad in India and people should realize that it will be much easier now to rationalize scientific research under Government auspices, than it will later on. Each year's delay will give existing interests longer to dig in, to find better and better reasons why drastic change should not be made. We are well used to all that here. But if one believes that the only hope for a happy and prosperous future in India is by the steadfast use of scientific knowledge and scientific method, then drastic change must be made, and the sooner the better."

Cordite

FROM the field of use as a propellent, cordite and similar materials are expanding into new techniques. They are being used as convenient sources of portable power. A common application to-day is in the starting of aeroplane engines, where suitable cartridges produce controlled pressure. Another use in the same sphere is in rockets for assisting the take-off of flying craft. From the point of view of air defence rockets have shown their value in anti-aircraft artillery, while more recently the activities of the Typhoons have shown the great work that can be done in the realm of tank destruction and special target hitting. Behind all this lies the mastery of propellents.

For over 50 years cordite has been used as a propellent by the British Army. The replacement of gunpowder by cordite only became possible with the development of chemical engineering during the Victorian period. Until nitric acid could be produced in large quantities, cordite and all the other nitro compounds had no chance. In the early part of the century, saltpetre reigned supreme, and technical emphasis was on the development of the rifle from the smooth-bore musket. The famous cartridges which were the subject of the incident that precipitated the Indian Mutiny contained gunpowder. The Colt and the Gatling relied on gunpowder as propellent.

But the chemists were hard at work. Pelouze, in 1838, obtained a highly inflammable material by treating cotton with strong nitric acid. In 1845, Schonbein improved this technique by using a mixture of nitric and sulphuric acids for the nitration of cotton. He noted the explosive properties, and sold the British rights of the process to John Hall and Sons, of Faversham. This firm abandoned the project after a disastrous explosion occurred at the works in 1847. About the same time the Italian, Sobrero, prepared nitroglycerine. But for the commercial exploitation of this product suitable means had to be developed to prepare glycerine from the "sweet water" of the soap works. At first only the glycerine from the candle factories was suitable. To concentrate this there was needed an efficient machine—the first to gain recognition as being suitable for evaporation was not built until 1843—but more problems had to be solved before "sweet water" could be handled. Salting-type evaporators operating under vacuum were not introduced until after 1870.

Gun-Cotton

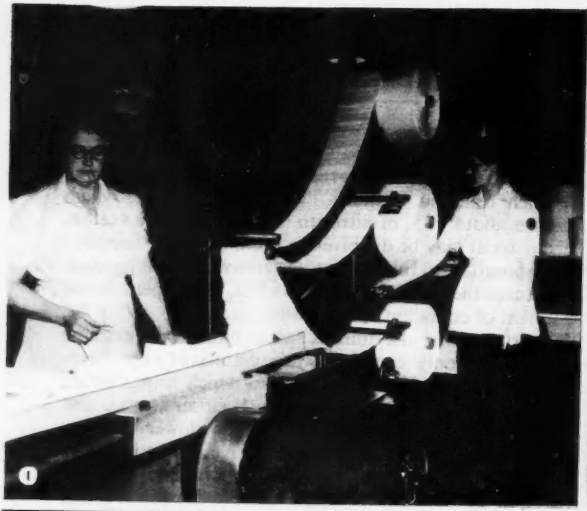
The method of handling the nitrated materials took a long while to develop. While Frederick Abel was working on the safe manufacture of gun-cotton, Alexander Parkes of Birmingham made the first steps in the production of celluloid. It was discovered that cotton could be nitrated in varying amounts, and that stronger acid was needed to reach the maximum nitration. The different products varied in their properties and a range of uses was suggested for them. The lower nitrates which contain about 10% by weight of nitrogen are alcohol soluble, and the solution in equal parts of alcohol and ether is known as collodion. The nitration product, therefore, is called collodion cotton. Both this grade and the more highly nitrated products look very like the cotton from which they derive and are fibrous in structure. It was found that by treating the fibrous mass with about 30% of camphor and kneading it there could be formed a horny material. This is the way in which celluloid is made. The higher nitrate, which contains about 13% of nitrogen, is known as gun-cotton. This material may be dissolved in acetone or ethyl acetate. On evaporating off this solvent a gelatinous mass is formed; in this case the fibrous structure is lost, as happens in the treatment of collodion cotton with camphor.

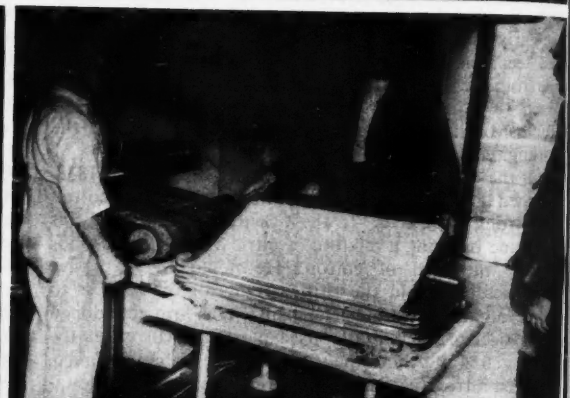
Gun-cotton, in the fibrous state, burns with extreme rapidity, and only explodes when detonated. On treatment with a solvent such as acetone which brings about gelatinisation the product has a much closer texture and the explosion wave travels with a much lower velocity. Gun-cotton is a powerful high-explosive, but it is not as powerful as blasting gelatine. Many accidents occurred with gun-cotton, but research by Sir Frederick Abel showed that this was due to traces of acid or acid-forming substances in the material. These impurities may lead to cumulative decomposition and final explosion. Abel found that the simplest way to stabilise gun-cotton was to boil it for a long time in several batches of water in this way disposing of the traces of acid left from the nitration process. Some such process of stabilisation is found to be necessary for all similar nitro compounds, and for some other varieties of cellulose derivatives. After stabilisation the gun-cotton is reduced to pulp in an engine beater, like that used in paper mills, and the broken fibres are drained and formed into useful shapes under pressure. By keeping the gun-cotton moist it remains fairly insensitive to shock, and for bulk storage this is the recommended method. The new manufacture of gun-cotton was undertaken by the Government at Waltham Abbey.

Alfred Nobel was responsible for developing nitroglycerine as a blasting explosive. This extremely powerful explosive was shown to be effectively brought into action by the use of a detonator, particularly by mercury fulminate. But nitroglycerine was very dangerous to handle and hazardous to manufacture. Nobel circumvented the danger of handling liquid nitroglycerine by absorbing it in diatomaceous earth. This product was detonated more readily than the original compound, but it did not produce such a powerful blasting effect. The dynamite patent was taken out in 1867 and a large factory at Ardeer was set up for its manufacture in 1871.

Further work by Nobel showed that it was possible to use nitrocellulose as an absolvent base for nitroglycerine, instead of the diatomaceous earth used in his first dynamite. Thus in 1867, instead of an inert base, he had tried gun-cotton. This was unsuccessful. The story runs that some years later having a cut on his finger he applied a coating of collodion to protect it. At the time he was working with nitroglycerine and he found that it united with the collodion cotton. This led him, in 1875, to mix nitroglycerine with collodion cotton in the presence of a solvent. This was the invention of blasting gelatine, which is much more powerful than ordinary dynamite, and is unrivalled for blasting hard rock.

The explosives which have been mentioned up to now





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have value because they are high-explosives. The gunpowder used in the cartridge does not function as a high-explosive but burns at a controllable rate, so producing a pressure adequate for the projection of the bullet without unduly straining the gun barrel. This is the function of a propellent. Gunpowder, of course, could also be used as a high-explosive, but by the 1860's dynamite and gun-cotton were challenging its position. At the same times attempts were made to use nitrocellulose as a propellent by reducing its rate of combustion. The best results were obtained by the use of gelatinising solvents. In 1886 the first satisfactory propellent was obtained by Vieille. This product was used for rifle ammunition by the French and was the well-known "Poudre B". It was made from a mixture of gun-cotton and collodion cotton gelatinised with ether-alcohol and formed into small squares.

Coupling Two High-Explosives

By 1888 Nobel had made his remarkable discovery that by gelatinising nitrocellulose with nitroglycerine it was possible to produce a slow-burning propellent. By this discovery the two most powerful high-explosives of the time were tamed, and their power turned along different avenues of use.

At the same time Sir Frederick Abel and Sir James Dewar produced a similar material which was called cordite. Patent lawsuits ensued, but they went against Nobel. Cordite Mark I, which was first manufactured in 1890, contained 58% nitroglycerine, 37% gun-cotton, and 5% mineral jelly. The large proportion of nitroglycerine had a high explosion temperature and produced serious erosion of the gun bores. To overcome this defect there was produced Cordite M.D. in 1901, which contained 65% gun-cotton, and 38% nitroglycerine. During the 1914-18 war it was found necessary to change the formula again owing to the shortage of acetone which was the gelatinising solvent. To get round this shortage it was necessary to use a variety of nitro cellulose which would dissolve in a mixture of ether and alcohol. Thus collodion cotton was substituted for gun-cotton. To compensate for the absence of gun-cotton the proportion of nitroglycerine was raised so that the ballistic properties of the cordite remained the same. This new formula, devised by Research Department, Woolwich, became R.D.B. Cordite. This was for land use. It must be pointed out at this stage, that in this country the naval cordite is made by a separate organisation, not connected with Woolwich. The leading factory is the Royal Naval Cordite Factory at Holton Heath. During the period of acetone shortage in the Great War, this factory turned to the manufacture of acetone by the fermentation method.

During the last war there was manufactured in this country some 139,000 tons of cordite, and the production capacity was about 2000 tons per week. At this rate there was needed 440 tons of acetone per week, but in view of the shortage of this material solvent recovery methods were worked out which lowered the demand to 15-17% by weight of the cordite. Luckily the United States did not experience a similar acetone shortage because they used a different cordite formula which employed a gun-cotton having a lower degree of nitration than that used here, and this could stand ether-alcohol solvent.

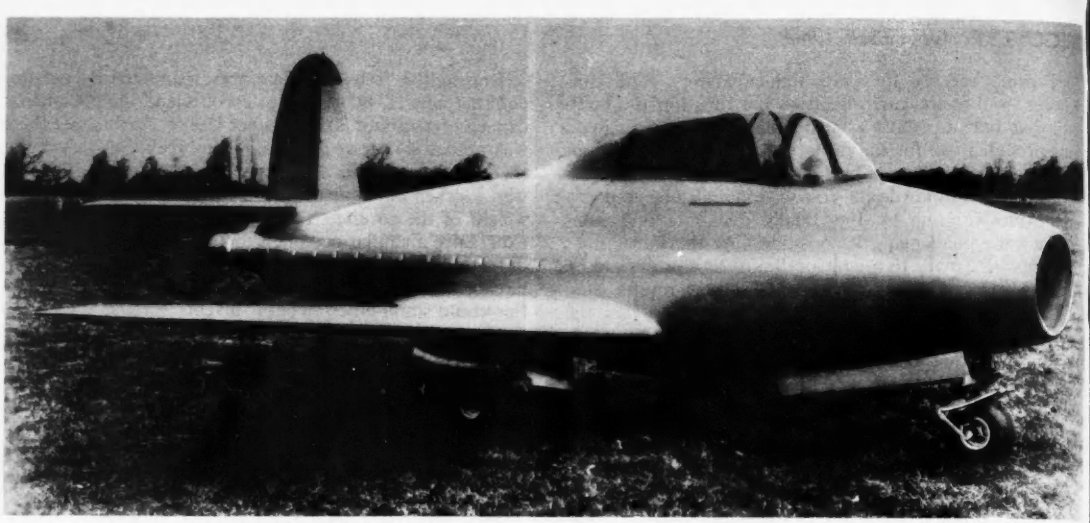
The manufacture of R.D.B. Cordite needed more precise control than was the case with the M.D. formula and it was found that considerable care needed to be taken in the preparation of the nitrocellulose. This was made from cotton which was obtained from cotton waste. In order to maintain constant viscosity of the nitrocellulose the percentage of nitration had to be kept within close limits.

Although the fundamental process of cordite manufacture has not altered, there have been a number of changes and improvements in its preparation and use. For example, with the progress of cellulose technology it has been possible to produce high-grade cellulose from wood pulp. Just as acetate rayon is now made from wood pulp instead of from cotton linters, so may gun-cotton and collodion cotton. The variety of wood pulp used is that prepared by the sulphite process. Various relatively complex organic chemicals are now used to help stabilise the nitro compounds, the method of stabilisation being based on the chemical neutralisation of the decomposition products, a common stabiliser being "centralite", which is dimethyldiphenylurea. In "Poudre B" diphenylamine is used. New ways have been worked out for simplifying nitration, and in the illustrations is shown a modern method. In this a coil or scroll of cellulose is dipped into the mixed nitric and sulphuric acids. After nitration this can be readily drained and washed, and it is then broken down to small particles which are readily gelatinised. On gelatinisation the mixture is extruded into thin rods or "cords"—hence the name *cordite*—and the solvent is dried off and recovered. The size of the cord is adjusted to give the required ballistic properties. This production of cords is essentially similar to the production of macaroni or rubber tubing, and uses the same type of machinery. Before the present war some countries were developing "solventless" double base powders. For instance, the French were using "Poudre S.D." which consisted of nitrocellulose, nitroglycerine, and a non-volatile gelatiniser. This technique is parallel to that employed in the plastics industry where, as has already been pointed out, camphor is used to plasticise nitrocellulose.

S.G.

These photographs showing how cordite is made were taken in a Royal Naval Armaments factory. **1.** *This machine, designed and developed at the Royal Naval factory, turns out paper scrolls, winding a layer of crinkled paper between two plain layers.* **2.** *The scrolls go into vats of acid, in which the paper is converted into nitrocellulose. Formerly the paper was torn into inch-square shreds before treatment. Using scrolls saves about half an hour in filling each vat.* **3.** *The nitrocellulose scrolls are put into this machine and turned into pulp.* **4.** *The pulp is whirled through this machine to remove dirt and lumps.* **5.** *Nitroglycerine and nitrocellulose are mixed. The cordite is produced in white doughy sheets.* **6.** *The cordite is processed into long, thin strings like macaroni. It is here being combed for short lengths.*

[Crown Copyright reserved



THE first British jet-propelled aircraft. Propelled by a gas-turbine unit to the design of Air Commodore Frank Whittle and built by the Gloster Aircraft Co., it flew for the first time on May 15, 1941. The engine of this prototype was mounted in the fuselage. The low tricycle undercarriage, which is fully retractable, can be seen in this photograph. (*Crown Copyright Reserved*).

Eve of Jet-Propulsion Era

FROM AN AIR CORRESPONDENT

ON a visit to the Second Tactical Air Force in France and Belgium recently, a high officer of the R.A.F. declared to me with emphasis that in two years all combat aircraft, particularly short-range fighters, would be jet-propelled, or reaction-propelled to use the term now current in the aeronautical press. Thus we do not have to look far ahead to the time when the Spitfire which, with only minor modifications, has served us so well since the Battle of Britain, will be obsolete, along with the Tempest, the Typhoon, the Mustang and the rest of the over-400 m.p.h. "orthodox" fighters.

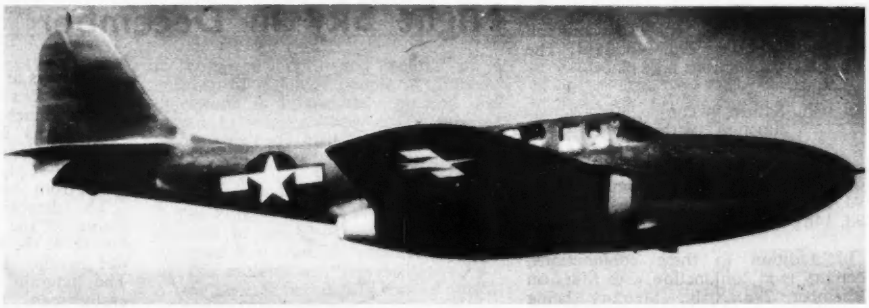
Notwithstanding the tremendous war-time development in internal combustion engines, both "in line" and "radial", I believe that officer's opinion to be the correct one. Jet propulsion is here to stay, and it is perhaps no idle thought to say that, excellent planes though they still are, the Spitfire and the rest of them are on the "way out." The application of jet propulsion to the great airliners of the late 1940's is already being planned, and in the meantime it is being tried out in short-range interceptor fighters. Britain, the United States and Germany, have all produced jet-propelled fighters.

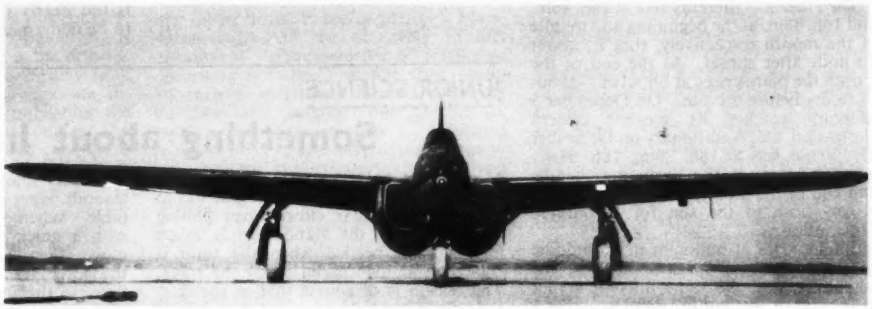
The British type, naturally, is still very secret, and few details are known about it outside the R.A.F., the Air Ministry and the Ministry of Aircraft Production. Royal Air Force jet-planes, of a type unspecified, but presumably developed from the Whittle aircraft announced early this year, have been in action against the flying bombs. But that, so far, has been the limit of their operational career.

Though the Germans have made increasing use of their Messerschmitt 262 "Schwalbe" in the Nijmegen-Arnhem sector, and against American bomber forces over Germany itself, there have not yet been any battles of jet-plane *versus* jet-plane. American fighter pilots, flying "orthodox" fighters—Mustangs, chiefly—with considerably less maximum speed, have shot down quite a few "Schwalben," and a Tempest pilot recently destroyed one over Holland.

Some of the secrecy concerning the British type was removed recently when a picture of the prototype built by the Gloster Aircraft Company over three years ago was released for publication. This is the Whittle aircraft, with a gas-turbine jet-motor designed by Air Commodore Frank Whittle, C.B.E., who has just been awarded the Gold Medal of the Royal Aeronautical Society for his work—only the eighth time this medal has been awarded since it was given to the Wright Brothers in 1909.

Whether the jet-plane now in service with the R.A.F. bears any resemblance to the 1941 prototype, I cannot say. But I doubt it. That prototype was a single engine aircraft. We now know that a twin jet-motor fighter, the P.59A Bell Airacomet, a modern, cleanly designed fighter, has been developed from it. The P59A has two Whittle type motors built by the American General Electric Company, and fitted at the wing-roots. A feature of its design is a very wide track under-carriage, but apart from the lack of propellers—a characteristic of all jet-propelled aeroplanes—it looks quite like any other two-motored fighter. It is a single seater, and reports from





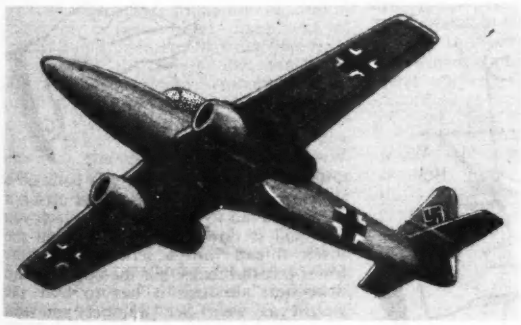
THE Bell Airacomet first American jet-propelled plane. The power units, to be seen on each side of the fuselage, have been developed by the General Electric Co. of America from Air Commodore Whittle's designs.

the United States indicate that it weighs five tons, has a wing span of between 40 and 50 feet, and is armed with four half-inch machine guns. There is no indication that any Airacomets have yet reached any of the combat zones. Other American reports speak of experiments by the U.S. Navy with jet-propelled carrier-borne fighters.

It would seem, therefore, that the initiative in putting jet-propelled aircraft into real action lies with the Luftwaffe.

From fighter-pilots in France and Belgium, I have gathered that the Messerschmitt 262, a twin-motored aircraft, has the appearance of an old Westland Whirlwind fighter. It has been used, carrying two 250 kilogram bombs, to attack British positions and the bridge at Arnhem. It has been used, too, for photographic reconnaissance work, but so far there are no reports of it having been employed solely as a defensive fighter against British formations, though American Bomber formations have encountered a few of them.

DRAWING of Messerschmitt ME. 262 single-seat reaction-propelled fighter, powered by two Junkers Jumo 004 gas turbine units. According to the Germans its armament can consist of four 30 mm. cannon. Aeroplanes of this type fitted with bomb racks, have been reported in action against our forward troops in Belgium and Holland. ("*The Aeroplane*"—*Copyright*).



R.A.F. pilots to whom I have spoken, believe that the Me. 262's they have met have been unarmed. At least, all of them have moved off, with all the extra-speed that jet propulsion gives them, at the approach of our fighters.

The Me. 262 has a probable maximum speed of over 520 miles an hour—which means, perhaps, an advantage of about 100 miles an hour over British "orthodox" fighters. It has a flying duration of about an hour and a half. One disadvantage of this high speed is the limitations imposed upon manoeuvrability, and there has been at least one report of a Me. 262 crashing through trying to alter course too quickly. Some experts believe that the number of men available to any nation who can stand the strain of such high-speed flying is limited, but one argument against that is that we thought just the same when the maximum speed of a fighter was 300 m.p.h.

Germany has been working on jet-propulsion for some years, and in addition to the Messerschmitt concern, the Heinkel, Junkers, B.M.W., and Henschel concerns are known to be interested. B.M.W. and Junkers have been turning out the turbines, the others have designed airframes suitable for jet-propelled units. Professor Otto Mader, for many years one of the right hand men of the Junkers concern, who has just died, is believed to have been largely responsible for the design of the Jumo 004 jet-propulsion unit with which the Messerschmitt 262 is fitted.

Night Sky in December

The Moon.—New moon occurs on December 15d. 14h. 34m. U.T., and full moon on December 29d. 14h. 38m. The following conjunctions take place:

December				
2d. 08h.	Saturn in conjunction with the moon	Saturn	0·1°N.	
8d. 09h.	Jupiter	,,	Jupiter	4 S.
16d. 17h.	Mercury	,,	Mercury	1 S.
19d. 00h.	Venus	,,	Venus	0·2 S.
29d. 14h.	Saturn	,,	Saturn	0·3 N.

In addition to these conjunctions, Mercury is in conjunction with Mars on December 29d. 05h., Mercury being 3·6°N.

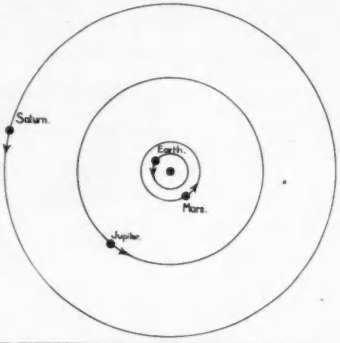
The Planets.—Mercury sets at 16h. 46m. and 16h. 48m. at the beginning and middle of the month respectively, that is, about an hour after sunset. At the end of the month the planet rises at 6h. 41m.—about 1½ hours before the sun. On December 5 Mercury reaches its greatest eastern elongation, and is stationary on December 13. Venus sets at 18h. 20m., 18h. 58m., and 19h. 46m. at the beginning, middle and end of the month respectively. Mars is too close to the sun for favourable observation.

Jupiter rises at midnight in the middle of the month, 47 minutes later at the beginning, and the same interval earlier at the end of the month. On December 1 Jupiter is 522 million miles from the earth, and on December 31, the distance has decreased to 478 million miles. Saturn rises early in the evening at 17h. 57m., 16h. 53m., and 15h. 43m. at the beginning, middle and end of the month respectively. On December 1 Saturn is 760 million miles from the earth, and on December 31, the distance is 748 million miles; the planet is in opposition on December 29. Those who wish to search for Uranus will find it close to the star γ Tauri.

Times of rising and setting of the sun and moon are given below, the latitude of Greenwich being assumed:

December	Sunrise	Sunset
1	7h. 43m.	15h. 54m.
15	8h. 00m.	15h. 51m.
31	8h. 06m.	15h. 56m.
December	**Moonrise**	**Moonset**
1	17h. 24m.	9h. 02m.
15	7h. 34m.	16h. 01m.
31	18h. 03m.	9h. 31m.

The upper limbs of the sun and moon are on the horizon at the times given, and refraction is allowed for. In the case of the planets the computations are always made without taking refraction into consideration. It is not worth while allowing for refraction when we are dealing with the planets, because they cannot be seen until they are several degrees above the horizon, and refraction makes a difference of a few minutes of time only. The following example will show the effect of refraction. On December 1, taking refraction into consideration, Saturn rises 4 minutes earlier and sets 4 minutes later in the latitude of Greenwich. At the latitude of 53° Saturn rises 7 minutes earlier and sets 7 minutes later than occurs at the latitude of Greenwich. As variations of latitude in the British Isles are much greater than that given by assuming 53° instead of 51½, it is obvious that only approximate results can be expected at places with latitudes differing much from that of Greenwich.



The diagram shows the relative positions of the Earth, Mars, Jupiter and Saturn at the middle of December. The dot in the centre represents the Sun. The diagram shows why Mars is not easily seen. The Earth, the Sun and Mars are almost in a line and hence Mars is too nearly in the direction of the sun to be conveniently observed.

M. DAVIDSON.

JUNIOR SCIENCE

Something about Inertia

MASS is not only heavy—it is also inert. You all know that a railway engine has to put in a particular effort when pulling a train out of the station, while much less work is needed when the train is travelling at high speed along the track. The reason is of course that at the start the engine has to overcome the inertia of the train—it has to bring the train from a state of rest to a state of motion. To do that the engine has to do work. Once the train is moving evenly at a certain speed, the only work the engine has to do is to overcome the friction of the wheels and the resistance of the air. If the train could travel in a vacuum and on a perfectly smooth surface, that means if all friction could be excluded, the engine would have to do no work at all to keep the train in the state of movement. If the train has to stop, again work has to be done because the train's inertia wants to keep it in the state of motion. Again a force has to be applied, but this time in the opposite direction. Let us put it this way: at the start work has to be done and at the stop work is gained. This work which is gained is changed into heat in the brakes.

Once you think of it, you will find that you encounter the inertia of bodies many times in many different forms every day. Here are two examples, which will demonstrate to you inertia of mass. Place a tumbler filled with water on a strip of smooth paper near the edge of a polished table. When you pull the paper away with a quick jerk, the tumbler will not move (Fig. 1). The explanation is that the force was applied for too short a time, so that not enough work was done to move the tumbler.

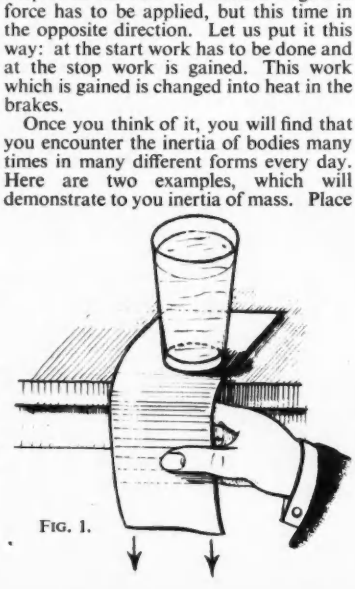


FIG. 1.

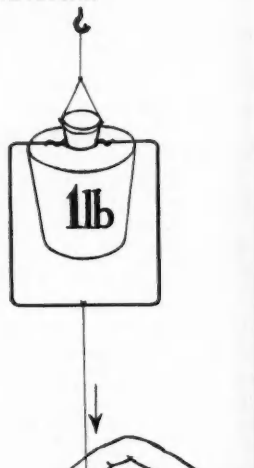


FIG. 2.

In the other experiment you hang up a weight on a cotton thread, and attach a second thread to the weight by which you can pull it downward. If you pull the lower thread with a jerk (Fig. 2), the lower thread breaks, but the upper thread does not, although it has to bear the weight as well. See whether you can puzzle out the reason; it is not quite so simple as it seems. (Answer on page 352).

K.M.

The Bookshelf

The Journey Home. Mass-Observation Report on the problems of demobilisation. (John Murray, 6*s*.).

THE title of this study refers not, as one might expect, to the return from work, but to the return from the services and war-industry—demobilisation. The topic is even more topical now than when the survey was made, but it is doubtful if this book will contribute very much to the discussions going on.

It is an examination by Mass-Observation of what people *think* about some of the problems of demobilisation. It seeks to convey the cynicism, hopes, fears, and expectations of the people of this country. What it succeeds in conveying (and this is recognised by the authors) is the obvious writ large. What then, one may well ask, is the point of this elaborate investigation, or, at least, of publishing the results? Presumably it is to convince the unconvinced that this was the true picture of the people's views or feelings on this issue. It is then of considerable importance to examine the validity of the methods of investigation.

It is rightly argued that this is a problem of the whole community, not just of those in the Forces or Civil Defence. Civilian opinion was gleaned by (a) 570 interviews—half in London, the remainder spread over Manchester, Bolton, Newark, Bishop's Auckland and some Hampshire villages (b) the statements of M-O's. National Panel of Voluntary Observers reporting the beliefs and feelings of the Observers and their friends (c) a series of smaller investigations and material on M-O's files.

The basis of the statements about the views of those in the Forces is nowhere clearly stated: most comes from Voluntary Observers and there is one reference, on p. 53, to the fact the "M-O has little access to members of the forces stationed outside this country." This does not inhibit their presentation of one letter on the same page as "neatly synthesizing for the M.E.F. much of what we have just said of the Home Forces."

The philosophic basis of M-O appears to be strongly idealistic since, in their view, "more important than the stability of the bridge is people's belief in its stability."

They reject the possibility or desirability of a quantitative assessment of opinion and maintain that the important problem is to convey the qualitative nature of the opinion. A curious argument is put forward on p. 9. "It is the *figures*, the *statistics*, which are liable to alter suddenly, unpredictably, under new stimuli. The underlying mood, the *qualitative* picture, is too firmly established for sudden change to be effected under any immediately foreseeable conditions." (Author's italics.) What exactly this means is not at all apparent, but it implies a completely subjective interpretation of mood and feeling. It savours of reliance on intuition, for how does one assess the intensity with which a view is held, and when M-O attempts to compare hopes and desires of a number of different people at different dates one is immediately puzzled and driven to inquire "how many subjects whose views are held less intensely than at the earlier time are to be regarded as neutralising the increased ardour of another ten persons?"

The bulk of the material in the book consists of reports from the panel of Observers: these Observers are regarded by the authors as "representative, not of the general population, but of intelligent, informed opinion." This is a rather smug self-conceit that inevitably prompts the query "what makes a person a Mass-Observer?" Are the observers in fact necessarily "representative of intelligent informed opinion," or are they somewhat odd individuals representative of nothing and nobody but themselves, while the real intelligent, informed opinion-holders are busy doing things of rather more importance than examining their own and other peoples' mental navels.

The data put forward, therefore, will tend to confirm in their opinions those who held like views before reading the book, but will not disturb others out of their maintenance of any opposing ideas. As a collection of individuals' opinions it has its interest, but as a scientific study and assessment of opinion it has little value. R.G.F.

British Maps and Map-Makers. By EDWARD LYNAM. (William Collins, 1944; pp. 48 + 8 pls. in colour and 22 illustrations in black and white; 4*s*. 6*d*. net.).

THERE can be few people for whom maps, and especially old maps, have no appeal. Their number will dwindle appreciably if many among them are fortunate enough to get hold of this little book by the Superintendent of the Map Room of the British Museum. After a brief reference to the maps of the early world, beginning with Babylon, of which we have knowledge, he traces the development of cartography in Great Britain from the map of Matthew Paris and his pupils made at St. Albans in 1250, down to the latest edition of the maps of the Ordnance Survey. These last, as Mr. Lynam says, are admitted now to be the best in the world, the most informative and the most artistic. By following the development of technique in surveying and recording, in draughtmanship and method of production as described in this brief survey, even those least practised in map-reading will come to appreciate that these examples of the map-maker's skill, each in its respective period, in addition to its primary purpose, is a valuable sociological document which reflects the interests, pursuits and ambitions, permanent and ephemeral, personal and national, of the English people.

Mr. Lynam has been both liberal and judicious in providing his readers with illustrations. They range from the crude productions, half picture, half diagram, of early charts, road maps and records of monastic and private estates to examples of the great periods of British map-making such as that marked by the wonderful county maps of Saxton or the more florid later styles when continental map-makers 'Dutch and French had made their influence felt in England.'

E.N.F.

T.V.A.—Democracy on the March. By DAVID B. LILIENTHAL. (Penguin Books, 1944; pp. 208 + 15 illust.; 9*d*.).

THIS account of the now well-known Tennesse Valley Authority's tremendous sociological experiment, now in the eleventh year of its eventful life, is more subjective than that by Dr. Julian Huxley reviewed in the December 1943 number of this magazine. It is, too, a far fuller and more statistical review, as would be expected from the T.V.A.'s Chairman; yet as he says it is but a brief inventory. Nonetheless, no one who considers himself to be *au fait* with the working of this aspect of Mr. Roosevelt's New Deal can afford to miss reading this account by one of its chief professional administrators. Incidentally, the book is a reproduction of the U.S.A. edition, which was also published this year. P.V.D.

Short Notes

The ABC of Psychology. By C. K. OGDEN. (Pelican Books, 1944, pp. 144, 9*d*.).

ORIGINALLY published in 1929 this book will be useful to anyone anxious to begin a study of psychology, providing as it does a summary of the accredited opinion from which the growing science is tending to develop, and a useful bibliography.

Lend-Lease. By E. R. STETTINIUS. (Penguin Books, 1944; pp. 288, illust., 9*d*.).

FOR three years the author was Administrator of Lend-Lease, and he gives a first-hand account, with some of the inner history, of this vital mechanism of war supply. Though most of the time he is concerned with American aid to the other partners of United Nations, he does full justice to the assistance which America has received, in both supplies and services, from Great Britain and the Empire.

The Physical Basis of Personality. By V. H. MOTTRAM. (Pelican Books, 1944; pp. 124; 9*d*.).

PROFESSOR V. H. MOTTRAM here attempts to assess how far personality is determined by a person's physical attributes. The first third of the volume is devoted to a statement of some of the facts established by cytologists and geneticists. Then follow two chapters, which will greatly intrigue the layman, on the nervous system and endocrine glands. The book ends with a recapitulation and coda in which Professor Mottram is able to capture the attention of those who know enough biology to skip the first 90 pages.

Far and Near

Patent Reform: Chemists' Views

PATENT legislation is an important factor conditioning the way in which scientific discoveries find commercial application, and the possibility that existing British Patent Law may be modified as an outcome of the deliberations of the Departmental Committee on Patent Law recently set up by the Board of Trade is causing interest in scientific circles. A number of scientific bodies and also many individual scientists have already submitted evidence to the committee. One of the most important memoranda on the subject which has been published is that of the Joint Chemical Committee on Patents. On this Joint Committee are represented the Association of British Chemical Manufacturers, Biochemical Society, British Association of Chemists, Chemical Society, Institution of Chemical Engineers, Royal Institute of Chemistry, Society of Chemical Industry and the Wholesale Drug Trade Association.

The memorandum, which has been submitted to the Board of Trade's Committee, confines itself to those points which apply particularly to chemistry and chemical industry. It begins by stating that it is the firm conviction of the Joint Committee that any amendment of the Patent Law should include such provision for the enlargement of the powers of the Comptroller of the Patents Office as will have the effect of reducing the number of invalid patents granted and of bringing the standard of validity in the Patent Office into line with that which obtains in the Courts. "Invalid patents in the hands of wealthy concerns" it comments "have considerable nuisance value, and the inconvenience and expense they cause to the meritorious inventor to the manufacturer and to the public cannot be eliminated merely by schemes for the reduction of litigation costs. The Joint Chemical Committee urges, therefore, that special consideration should be given to suggestions designed to reduce to a minimum the granting of invalid patents."

"Restraint of Trade"

The committee proceeds by setting out its answers to fourteen questions in the questionnaire circulated by the Board of Trade Committee for the guidance of witnesses. As to the complaint that British patents are used to the detriment of public interest, for forming cartels for suppressing and retarding competitive industrial developments, etc., the Joint Committee expresses the view that the abuses of patent monopoly by the suppression of inventions so often charged against patentees in the popular press are usually found on examination either to be non-existent or to be due to the abuse of the power of wealth. "As it is possible for a company or group of companies to hold a network of patents —most of which may be invalid—the way is opened to restraint of trade, the formation of cartels based on the patent position, and the threat of costly legal actions. In our view the remedy lies in refusing grant of invalid patents, the strengthening of Section 27, some considerable reduction of the costs of a successful defendant in the Patents Court. Section 27 of the Acts is intended to provide a remedy for every abuse of patent monopolies but there are certain directions in which amendments to improve interpretation and procedure might be made."

The committee admits the truth of the statement that possibly not more than 10% of all patented inventions are worked, and gives some of the reasons why this happens.

"Licences of Right" Rejected

It suggests that where a patent is being worked abroad and the product imported into the United Kingdom under an agreement with a British licensee who agrees not to work the invention in Britain but to obtain all the requirements of the British market from abroad, or where the proportion of the manufacture in Britain is negligible, the Comptroller should be given additional powers to grant a compulsory licence without royalty, and in extreme cases to exclude the patentee and his original licensee from manufacturing or selling under the patent. Patents for inventions relating to foods and medicines should continue to be dealt with specially as provided in the section —No. 38A (3)—of present Acts that cover this particular aspect of patent legislation; it is considered that the Comptroller should thus be able to exercise a supervision over the compulsory working of such patents.

The Joint Committee is against the proposal that all patents should be endorsed "Licences of Right" either on grant or after three years.

Under the present law patent actions go on trial in the first instance before one of the Chancery judges, with right of appeal, in succession, to the Court of Appeal and to the House of Lords. The Joint Committee suggests that patent actions and all patent matters dealt with by the High Court and the Patents Appeal Tribunal should be heard by a special Patents Division of the High Court consisting of three judges, appointed from among barristers who have had patents experience, together with one or two lay members selected from a permanent panel, of say, 6 to 8 technically and scientifically qualified persons. The technical panel, whose members should not undertake any other employment, should together cover the whole of the science and technology met with in patent specifications in the sense of being competent severally in their own spheres to understand such documents with the minimum of instruction by counsel and witnesses. The full Court should hear infringement and revocation proceedings; other patent matters should be heard by a court of one judge and one lay member, reference of such matters to the full Court to be made at the direction or by leave of the two-membered court.

The representatives of the Chemical Society, Royal Institute of Chemistry and the Society of Chemical Industry signed this report purely in a personal capacity, so that these bodies are not committed to the views expressed in the memorandum. One member of the Joint Committee, Dr. G. H. Frazer of the Therapeutic Research Corporation, dissented from two of the conclusions reached in the memorandum, and his minority report is published at the end of the document, which is obtainable from the Association of British Chemical Manufacturers, 166 Piccadilly, London, W.1, price 1s. post free.

A.Sc.W. Memorandum on Patents

AMONG other bodies that have submitted memoranda to the Patents Committee is the Association of Scientific Workers, whose recommendations can be summarised as follows: Patents, the A.Sc.W. considers, should normally be endorsed "Licences of Right" at the date of grant. The present grant of monopoly is considered especially unjustified when (a) an invention discloses only a very small step in scientific development; (b) an inventor is merely the first of a number of true inventors solving a known problem at about the same time, or (c) an invention has a short useful life.

Where, in certain exceptional circumstances, a grant of monopoly may prove in the public interest, it is recommended that the onus of justifying such grant should lie with the applicant.

In order to protect the public against possible secret working of processes, it is recommended that a patent should be the only form of industrial property in invention to be recognised by law and that no action should lie for breach of confidence by disclosure of technical information. As a corollary, it is recommended that the publication or use of an invention, within a specified period of 6 or 12 months, should not invalidate a patent application made at the end of that period.

It is recommended that the examination of inventions by the Patent Office should be extended to cover subject matter and that the quantum of invention necessary for a valid patent application should be substantially greater than the "scintilla" at present required. As a consequence, it should be made impossible for an opponent to involve an applicant in heavy expenses by an opposition proceeding, or himself to achieve an advantage by incurring greater expense than the applicant.

Synthetic Sapphires

THE large-scale manufacture of synthetic sapphires has started in Britain during this war. Hitherto this country had been dependent upon imports of this material. An interesting account of this develop-

ment is given in a recent issue of the *G.E.C. Journal*. Synthetic sapphires, it is pointed out, are *real* sapphires—the two are chemically the same substance. They are made by fusion of aluminium oxide of high purity and subsequent crystallisation. The first really workable process for making such synthetic gem stones was perfected by M. A. Verneuil at the beginning of the present century. The process now being used in Britain differs little in principle from that conceived by Verneuil. Before 1939 the production of synthetic gems had grown to very large proportions, being sited generally near the location of the watch-making industry since millions of jewels are used annually in the manufacture of watches. The chief centres of production were Monthey and Locarno in Switzerland, Bitterfeld and Zwickau in Germany, and Annecy and Garrie in France. These three countries supplied the great bulk of the synthetic gems used in the whole world, exporting a large proportion in the form of finished or partly finished jewels.

When war became imminent it was realised that navigation instruments, chronometers, altimeters, compasses and the like, on which the safety of aircraft, warships, tanks and crews depended, were in their turn dependent on the possession of frictionless bearings, *i.e.*, sapphires and rubies. No British source of jewel bearings was available and so at the request of the Ministry of Aircraft Production, representatives were sent to Switzerland to study the process in operation and to make arrangements for setting-up a similar plant in this country. The British Jewel Manufacturing Co., Ltd., was formed to undertake this work. The original intention was to import the raw material from Switzerland and to install furnaces in this country for making the actual sapphires or "boules." Before this plan came to maturity, France had fallen and Switzerland was effectively cut off from direct contact with this country. Plans had therefore to include the preparation of the raw material and the development of the subsequent processes without further recourse to Swiss experience.

Oxy-Hydrogen Flame Used

In 1940 work commenced and sapphires were first produced from a limited stock of Swiss aluminium oxide. At the same time steps were taken in conjunction with the Research Laboratories of The General Electric Co., Ltd., to put into being processes for the preparation of suitable aluminium oxide and furnace bricks to withstand the severe temperature conditions, while provision for adequate supplies of hydrogen and oxygen and the replacement of furnace parts generally had also to be made. The aluminium oxide is prepared by the ignition of ammonia alum of suitable purity. The process of sapphire manufacture consists of feeding this powder slowly through an oxy-hydrogen flame and causing it to fuse and subsequently to solidify and build up in a stalagmite-like way on a refractory support or platform. By controlling the speed at which the powder is fed to the furnace, and therefore the rate at which the sapphire material builds up, a single crystal of sapphire may be produced.

Pure alumina powder is generally used, giving a "white" sapphire for instrument jewels and other industrial purposes, but coloured stones, rubies and blue sapphires, may be made by incorporating the appropriate substances with the alumina. With this technique the size of crystal which can be conveniently built up is about 50-60 mm. in length, 20-25 mm. in diameter, and with a weight of about 60 grams (300 carats); such a crystal takes about 4-5 hours to grow.

A film was shown in London recently in which a demonstration of the Russian sapphire manufacture appeared. It seemed that the technique used was essentially that of Verneuil so that whatever developments may take place in the future it is clear that the method of setting about the problem as originally conceived by him was technically sound.

Who Will Be The Second?

THE Royal Society is amending its statutes to make it clear that women can be admitted as fellows. Since 1919 there has been no bar to women being proposed for fellowship, but this does not appear to have been generally known judging from the fact that only two women have been proposed in the intervening years. Apart from Queen Victoria no woman has ever been elected an F.R.S.

Personal Notes

THE following presentations were made at the recent general meeting of the American Chemical Society recently held in New York. MR. ARTHUR C. COPE received the American Chemical Society award in Pure Chemistry, and the Priestley Medal was given to PROFESSOR JAMES BRYANT CONANT, Harvard University.

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MR. OLAF FREDERICK BLOCH, well-known for his researches in photo-chemistry and formerly chief chemist of Ilford, Ltd. died last month in London at the age of 72. His early work was concerned with the improvement of panchromatic plates, then in their infancy, and later he contributed much to the perfecting of infra-red photography. Other developments in photographic technique for which he was responsible benefited many research workers. For instance, in close collaboration with Dr. F. W. Aston, F.R.S., he produced the "Q" plate, particularly designed for the recording of charged atomic particles of low penetration and used in Dr. Aston's studies of isotopes.

Consulted by astronomers throughout the world, Bloch produced many plates with special qualities for the photography of the moon, spectrographic examination of meteors, observation of the sun's eclipse and other purposes. Most important perhaps were the special emulsions evolved under his direction for the recording of atomic particles derived from cosmic rays, or produced through radio-activity or by the break-down of atoms by means of the cyclotron. He was awarded the Progress Medal of the Royal Photographic Society, and he was president of that society in 1934. He had contributed a number of articles to DISCOVERY.

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LAST month the Académie Française elected three new members, two of whom were scientists—PROFESSOR PASTEUR, VALLERY RADOT and PRINCE LOUIS DE BROGLIE. A *Times* correspondent reports that Professor Radot, who is a grandson of Pasteur, has won new fame under the name of "Monsieur Renoir" for the part he played in organising the medical service of the French resistance movement.

Another leading member of the underground movement has been PROFESSOR JOLIOT-CURIE, the physicist.

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THE Lord President of the Council has appointed MR. W. J. DRUMMOND, DR. H. L. GUY, F.R.S., SIR WILLIAM HALCROW, M.Inst.C.E., and MR. W. F. LUTYENS, to be members of the Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research from October 1. SIR JOSEPH BARCROFT, SIR HAROLD HARTLEY, and SIR FRANK SMITH retired from the Council on completion of their terms of office on September 30. Mr. W. J. Drummond is managing director of the Ashington Coal Co., Newcastle. Dr. H. L. Guy is secretary of the Institution of Mechanical Engineers and Associate Member of the Ordnance Board and of the Board of Chemical Warfare. Sir William Halcrow is a consulting civil engineer. Mr. W. F. Lutyens is a director of I.C.I., Ltd.

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LATE month VLADIMIR KOMAROV, President of the Academy of Sciences of the U.S.S.R., celebrated his 75th birthday. An outstanding geographer as well as a leading botanist, Komarov was the founder and leader of a team of scientists who produced the comprehensive *Flora of the U.S.S.R.* A decree of the Soviet Government commemorating the birthday of Academician Komarov confirms the decision of the Academy of Sciences to publish his biography and his selected works, and establish in the Academy of Sciences an annual "Komarov" prize of 20,000 roubles for the best work in the sphere of botany, and eight "Komarov" fellowships in botany at the Leningrad and Moscow Universities and the Academy of Sciences' Botanical Institute.

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MR. CHARLES BROTHERTON, head of a Yorkshire Chemical Company, has agreed to subscribe £1,000 a year for 7 years for the establishment of a research fellowship in chemistry tenable at Leeds University, and a further £1,000 for 7 years for a new lectureship in chemical engineering. In addition he has subscribed £2,000 for the provision of the necessary extra equipment.

PROFESSOR SIR ROBERT ROBINSON has been appointed chairman of the Water Pollution Research Board of the Department of Scientific and Industrial Research in succession to the late Mr. H. C. Whitehead.

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THE joint committee of the Royal Physical Society, the Royal Scottish Geographical Society, and the Royal Society of Edinburgh have awarded the Dr. W. S. Bruce Memorial Prize 1944 to LIEUT. T. H. MANNING, R.C.N.V.R., for his valuable survey and biological work from 1931 to 1939 in Iceland, Lapland, Southampton Island, Hudson Bay, and at Foxe Basin (1936-1939).

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MR. J. G. BENNETT has left the British Coal Utilisation Research Association of which he was director. His successor has not yet been appointed.

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THE death occurred on October 23 at the age of 67 of PROFESSOR CHARLES GLOVER BARKLA. He had been professor of Natural Philosophy at Edinburgh University since 1913. Born at Widnes, he graduated at University College, Liverpool, and then proceeded to the Cavendish Laboratory where, under the direction of J. J. Thomson, he started to investigate the velocity of electric waves in wires. In 1905 he discovered the phenomenon of "self radiation", showing that metals which were subjected to X-rays radiated secondarily rays that were just as characteristic of the respective metals as were their optical spectra. This work formed the foundation on which a few years later X-ray spectroscopy could be developed. He was appointed demonstrator and assistant lecturer in physics at Liverpool in 1905, and in 1907 he became lecturer in advanced electricity. Two years later he came to London as Wheatstone Professor of Physics at Kings College, where he remained until he was appointed professor at Edinburgh University. Elected an F.R.S. in 1912, he was Bakerian Lecturer in 1916 and Hughes Medallist of the Royal Society in 1917. In the latter year he was awarded the Nobel Prize in physics.

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Royal Institution: Christmas Lectures

SIR HAROLD SPENCER JONES, the Astronomer Royal, is delivering the "children's lectures" at the Royal Institution this Christmas. This course of six lectures, the 115th in the series, has the title "Astronomy in Our Daily Life" and begins on December 28 at 2.30 p.m. For children the subscription for the course is half-a-guinea; adults, one guinea.

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Personal Notes

THE French scientist DR. ALEXIS CARREL, who was awarded the Nobel Prize in 1912 "in recognition of his work on vascular seams and on the transplantation of vessels and organs", died on November 4 at the age of 71. His work on the suturing of blood vessels was of importance in the development of blood transfusion. Much of his research into the growth of tissues outside the body—tissue culture *in vitro*—was done in America, at the Rockefeller Institute for Medical Research, New York.

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1943-44 Nobel Prizes

THE 1943 Nobel Prize for physiology and medicine was awarded jointly to PROFESSOR KENDRIK DAM and PROFESSOR EDWARD ADELBERT DOISY. The former discovered vitamin K, and Professor Doisy was responsible for ascertaining its chemical constitution. The award for 1944 has been made jointly to PROFESSOR J. ERLANGER and PROFESSOR HERBERT S. GASSER, for their discovery of the manifold functional differentiation of the nerves. Professor Dam is a Dane, the other prizewinners being Americans.

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THE death occurred on October 31 of Professor Joseph Hubert Priestley, aged 61. Head of the Department of Botany at Leeds since 1911, his researches were mainly concerned with plant physiology and developmental anatomy. He was president of the botany section of the British Association in 1932, and had close connections with the Yorkshire Naturalists' Union.

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DR. CHARLES G. ABBOT, director of the Smithsonian Astro-physical Observatory and Secretary of the Smithsonian Institute has retired from these positions. As a research associate of the Institute he will continue his researches relating to solar energy and its uses.

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History of Science Museum at Cambridge

THE nucleus of a History of Science Museum for Cambridge University is provided by the gift of a collection of old scientific instruments and books from Mr. R. S. Whipple. Mr. Whipple has also offered a sum of £3300 to start a fund for the purchase of instruments, models and books.

The collection includes a wide variety of sundials, quadrants, sextants, telescopes, microscopes (including a copy of one with which Leeuwenhoek made his remarkable observations), surveying and measuring instruments, and first editions of the works of such men as Gilbert, Galileo, Newton and Darwin. On November the Vice-Chancellor accepted the gift on behalf of the University. In opening an exhibition of the collection, Sir Henry Dale, president of the Royal Society, said he hoped that, besides a museum, Cambridge would soon possess organised courses of lectures in the History of Science and a department with at least a Reader and eventually a full Chair. The History of Science, he remarked, provides a common meeting ground for the various specialised sciences, and for the sciences and the arts.

Mercator's 350th Anniversary

THIS month sees the 350th anniversary of the death of Gerardus Mercator, mathematician and a geographer who produced the "projection" used in map making which bears his name. Mercator was of Flemish origin and was born at Rapelmonde in 1512. He studied at Louvain and about 1540 he produced a map of Flanders based upon his own surveys; a copy of this map existed before this war in the Musée Plantin in Antwerp. Charles V ordered from Mercator a set of instruments for use in his campaigns about this time. In 1538 Mercator's map of the world in two—north and south—hemispheres was produced and later terrestrial and celestial globes were made.

At one time Mercador had to go into hiding in Antwerp on account of his religious beliefs. In 1544 he was arrested and prosecuted for heresy, but he escaped any severe penalties.

In 1552 he accepted the chair of cosmography at the newly established University of Duisburg. Two years later he gave the world a map of Europe in six sheets and engraved William Camden's map of the British Isles. In 1568 came his planisphere for use in navigation. This was the first map to be made on "Mercator's Projection". It was not until about 1630 that this projection came into general use, with parallels and meridians at right angles.

Many more maps followed in which Mercator was aided by his son, Rumold. The geographer died on December 5th, 1594 and was buried in St. Saviour's Church in Duisburg. Mercator's fame lies in the method of projection which he invented and in the way he freed geography from the influence of Ptolemy. In his craft, both in map making and instrument work, is to be seen the skill and execution of detail which made Mercator one of the world's great geographers.

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Sugar Research in America

RESEARCH awards totalling more than $250,000 to various universities and colleges for scientific investigations of the chemistry of sugar and its rôle in the diet were recently announced by the director of the U.S.A. Sugar Research Foundation which is sponsored by the leading members of the beet and cane sugar industry.

Junior Science

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